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ANNUAL REPORT

OF THE

GEOLOGICAL SURVEY

OF

PENNSYLVANIA

FOR

1886.

IN FOUR PARTS.

PART I. PITTSBURGH COAL REGION.
PART II. OIL AND GAS REGION.
PART III. ANTHRACITE COAL REGION.
PART IV. MISCELLANEOUS REPORTS.

By the State Geologist.

PART I.

HARRISBURG:
PUBLISHED BY THE BOARD OF COMMISSIONERS
FOR THE GEOLOGICAL SURVEY.
1887.

Entered, for the Commonwealth of Pennsylvania, in the year 1887, according
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By WILLIAM A. INGHAM,
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SURVEY HEADQUARTERS, 907 Walnut St., Philadelphia.

A list of the publications of the Survey is appended to this report.

To His Excellency, James A. Beaver, ex-officio Chairman of the Board of Commissioners of the Geological Survey of Pennsylvania :

SIR :—I have the honor to submit to the Board the report of Mr. E. V. d'Invilliers, Assistant Geologist, of his completed surveys of the Pittsburgh Coal Region. embracing that part of south-western Pennsylvania, which is underlaid by the Pittsburgh coal-bed.

Mr. d'Invilliers' report will prove of great practical utility to the coal operators of the region, and the tidal elevations which he has determined of the outcrop of the Pittsburgh coal-bed will be useful to oil and gas prospectors in giving them a basis from which to estimate the depth to be drilled in order to reach the geological horizon of the different oil and gas sands.

This report is supplemented by two important contributions on Pennsylvania bituminous coal-mining, by Mr. A. N. Humphreys and Mr. Selwyn Taylor respectively, and is accompanied by a memoir from the eminent and venerable palæo-botanist Leo Lesquereux, on the character and distribution of Palæozoic Plants.

These reports form part I of the Annual Report of the progress of the Survey in 1886 ; part II contains the report of Mr. John F. Carll, Assistant Geologist, on his surveys in the oil and gas region ; part III, with its accompanying atlas of maps and sections, written by Mr. Frank A. Hill, Assistant Geologist, relates to the progress of the work in the Anthracite Coal-fields, done under the direction of Mr. Charles A. Ashburner ; and part IV is composed of a number of miscellaneous reports on special subjects.

My summary report on the geology of Pennsylvania has fully occupied me the entire year and will soon be ready for the press.

During the year the general direction of the field and executive work of the survey was delegated to Mr. Ashburner, Geologist in Charge.

The aid which the Board has given me in carrying out my plans and the zealous co-öperation of my assistants, has permitted the accomplishment of a large amount of work and the attainment of results of great practical usefulness to the mineral industries of the State.

I am, sir, very respectfully,
Your obedient servant,
J. P. LESLEY,
State Geologist.

January 1, 1887.

ANNUAL REPORT, GEOLOGICAL SURVEY OF PENNSYLVANIA,

1886.

PART I.

REPORT ON THE

PITTSBURGH COAL REGION.

By E. V. d'Invilliers.

Supplemented by a report on the
General Mining Methods of the Pittsburgh Region.
By Selwyn Taylor.

And a report on the
Mining Methods of the Westmoreland Coal Company.
By A. N. Humphreys.

WITH 26 PAGE PLATES, 12 FOLDING MAPS AND SECTIONS BOUND INTO
REPORT, MAP OF WESTERN PENN'A, AND SHEET OF
SECTIONS IN POCKET, AND 1 TEXT CUT

ACCOMPANIED BY REPORT ON THE

CHARACTER AND DISTRIBUTION OF PALÆOZOIC PLANTS.

By Leo Lesquereux.

TABLE OF CONTENTS.

Page.

Members Board of Commissioners, ... iii

Survey Assistants, ... iv

Letter of transmittal, ... v

Table of contents, ... ix

List of illustrations, Annual Report, 1886, Part I, . xv

Report of work done in 1886 on the re-survey of the Pittsburgh Coal Region.

By E. V. d'Invilliers.

Chapter I—Introduction, ... 1

Chapter II—History and statistics, ... 5

  Geographical position, topography, etc., ... 8

  River interests, ... 11

  Shipments of coal by Monongahela Navigation Co., ... 17

  Coke shipments from the Monongahela river, . . 22

  Railway system, ... 23

  The coal industry, ... 25

Chapter III—Structural Geology, ... 30

  1. Bulger anticlinal, ... 32
  2. Claysville anticlinal, ... 33
  3. Brady's Bend anticlinal, ... 33
  4, Washington anticlinal, ... 36
  5. Pin Hook anticlinal, ... 37
  6. Roaring Run or Murraysville anticlinal, . . . 41
  7. Waynesburg anticlinal, ... 44
  8. Saltsburg anticlinal, ... 46
  9. Indiana or Blairsville anticlinal, ... 47
  10. Fayette anticlinal, ... 48
  11. Chestnut Ridge anticlinal, ... 49
  12. Laurel Hill anticlinal, ... 49

Synclinals of the region.

Page.
1. Burgettstown synclinal, ... 51
2. West Middletown synclinal, ... 51
3. Mansfield synclinal, ... 51
4. Nineveh synclinal, ... 52
5. Allegheny river synclinal, ... 53
6. Waynesburg synclinal, ... 53
7. Lisbon synclinal, ... 55
8. Greensburg synclinal, ... 56
9. Blairsville (Connellsville) synclinal, ... 57
10. Ligonier synclinal, ... 57

CHAPTER IV—Stratigraphical geology, ... 58
The Upper Barren measures, ... 58
The Upper Productive Coal measures, ... 63
The Barren measures, ... 74
The Lower Productive Coal measures, ... 79

CHAPTER V—Geology of Allegheny county, Upper Productive coal series and Lower Barren measures, ... 82
Northern Allegheny, Township geology, ... 84
Marshall township, ... 87
Pine township, ... 87
Richland township, ... 88
West Deer township, ... 88
Fawn township, ... 89
Harrison, East Deer, and Springdale townships, . 89
Indiana, Harmar, and O'Hara townships, ... 91
Hampton and Shaler townships, ... 93
McCandless township, ... 95
Ross township, ... 96
Reserve township and City of Allegheny, ... 97
Franklin township, ... 98
Ohio township, ... 99
Sewickley township, ... 99
Leet, Aleppo, and Killbuck townships, ... 100
Eastern Allegheny, ... 101
City of Pittsburgh north of the Ohio, ... 102
Penn township, ... 105

Page.
Plum township, ... 110
Patton township, ... 112
Wilkins and Sterrett townships, ... 115
North and South Versailles townships, ... 118
Southern and Western Allegheny county, . . 123
Moon township, ... 130
Findlay township, ... 131
Robinson township, ... 133
Stowe township, ... 133
North Fayette township, ... 137
Collier township, ... 142
South Fayette township, ... 147
Chartiers township, ... 156
Lower St. Clair, Union, and City of Pittsburgh south of river, ... 160
Scott township, ... 165
Upper St. Clair township, ... 170
Baldwin township, ... 175
Snowden township, ... 179
Mifflin township, ... 181
Jefferson township, ... 194
CHAPTER VI—Washington county, ... 199
Topography, ... 201
Transportation, stratigraphical geology, ... 202
Upper Barren measures, ... 202
Monongahela River (Upper Productive) measures, 206
Pittsburgh series, (Barren measures,) 208
Township geology, ... 208
Hanover, Smith, and Robeson townships, ... 209
Cecil township, ... 213
Mount Pleasant township, ... 215
Chartiers township, ... 217
Jefferson township, ... 222
Union township, ... 224
Peters township, ... 227
Carroll township, ... 233
Fallowfield township, ... 240
Allen township, ... 243

Page.
East Pike Run township, ... 247
East Bethlehem township, ... 251
CHAPTER VII—Greene county, ... 258
Surface geology, ... 260
Upper Barren measures, ... 262
Monongahela River series, ... 264
Pittsburgh series, (Barren measures,) 265
Township geology, ... 268
Morgan township, ... 268
Jefferson township, ... 270
Cumberland township, ... 272
Monongahela township, ... 276
Greene township, ... 279
Dunkard township, ... 280
CHAPTER VIII—Westmoreland county, general description, ... 284
Structural geology, ... 289
Upper Productive measures, ... 291
Barren measures, ... 295
Lower Productive coal measures, ... 296
Township geology, ... 297
North Huntingdon township, ... 300
Sewickley township, ... 305
Hempfield township, ... 311
South Huntingdon township, ... 316
Rostraver township, ... 320
CHAPTER IX—Fayette county, general description, . 328
Upper Barren measures, ... 334
Upper Productive series, ... 336
Township geology, ... 341
Washington township, ... 341
Jefferson township, ... 344
Perry township, ... 350
Brownsville township, ... 353
Luzerne township, ... 361
German township, ... 364
Nicholson township, ... 366
Spring Hill township, ... 370

Page.

CHAPTER X—Part I. General mining methods of the Pittsburgh region, by Selwyn Taylor.

Prospecting, ... 373
Surface plant, ... 375
Inclined Planes, ... 381
Check-house switches, ... 383
Entries, ... 384
Coal Cutting machines, ... 388
Rolling stock, ... 389
Wire-rope haulage, ... 392
Tail rope system, ... 394
Endless rope system, ... 397
Mine locomotives, ... 398
Drainage, ... 399
Ventilation, fans, ... 401
Mine employés, ... 403
Transportation from the mines, ... 403
Slope and shaft mining, ... 405

PART II—Mining Methods and Practice of the Westmoreland Coal Company, by A. N. Humphreys.

Early discovery of coal, ... 411
Development of the Irwin basin, ... 414
Classification of collieries and outside improvements, ... 416
Inclined planes, ... 419
Slopes, shafts and tunnels, ... 421
Underground work, ... 427
Wire-rope haulage at Larimer colliery, ... 431
Mine cars, ... 435
Methods of mining, ... 437
Mining machines, ... 438
The Pittsburgh coal, ... 446
Clay veins and Slack veins, ... 447
Faults, ... 451
Fire damp, ... 453
Railroad cars, ... 455

On the Character and Distribution of Palæozoic Plants.

By Leo Lesquereux.

Page.
Introduction, ... 457
Algæ, ... 458
Progress of Palæozoic land vegetation, ... 467
The Ferns, ... 469
Disbubution of Ferns; characters and affinities of the groups, ... 472
Archæopteris, ... 473
Megalopteris, ... 475
Neuropterids, ... 475
Alethopterids, ... 478
Pseudopecopterids, ... 478
Pecopterids, ... 479
Sphenopterids, ... 480
Calamarieæ, ... 483
Lycopodiaceæ, ... 490
Lycopodites, ... 490
Lepidodendræ, ... 491
Sigillariæ, ... 498
Cordiateæ, ... 507
Fossil seeds, ... 512
General remarks on the Coal Flora, ... 514

LIST OF ILLUSTRATIONS, ANNUAL REPORT, 1886, PART 1.

Page Plates and Text Cuts.

	Page.
Plan and section of Main entry,	374
Railroad tipple,	376
River tipple and incline,	378
Three kinds of gravity planes,	380
Check-house and switches,	382
Plan showing method of working,	386
Mine wagons,	390
Tail engine plan at Laurel Hill mines,	396
Ventilating furnace,	402
Plan of Oak Hill colliery No. 4 pit,	408
Inclined Plane,	418
Equipment for supply slope,	420
Truck and bucket for sinking shafts,	422
Mine wagons,	426
Mine wagon details,	428
Details of wire-rope haulage,	430
Mine car wheels,	432
Mine car hitchings,	434
Miners' tools,	436
Coal cutting machine,	440
Coal cutting machine in operation,	442
Automatic water elevator,	444
Typical section of Pittsburgh bed,	446
Clay Veins,	448
Three forms of faults,	450
Various forms of faults,	452
Sections of Pittsburgh bed near a fault,	454

MAPS AND SECTIONS ACCOMPANYING THIS REPORT.

	Page.
Four sections of Upper Barren measures, opposite page	60
Four sections of Upper Productive Coal measures, opposite page	64
Four sections of the Barren measures, opposite page	76
Map of Second Pool mines of Joseph Walton & Co., opposite page	384
Map of Youghiogheny Slope mines, opposite page	405
Map showing outcrop of Pittsburgh bed at Irwin, opposite page	416
Plan of Larimer Colliery tipple, opposite page . .	418
Map of Westmoreland Shaft plant, opposite page	424
Map of South Side colliery, opposite page . . .	428
Map showing Wire-rope haulage at Larimer colliery, opposite page	430
Plan of details of Wire-rope haulage at Larimer colliery, opposite page	432
Map showing Double-entry system of mining, opposite page	438
Columnar sections of Pittsburgh bed, in pocket, .	
Map of south-western Penn'a, in pocket, ...	

THE PITTSBURGH COAL REGION.

E. V. d'INVILLIERS, *Assistant Geologist.*

CHAPTER I.

Introduction.

The First Geological Survey of Pennsylvania was authorized by an Act of Legislature dated March 29th, 1836; but it was not until 1838, that a survey of the Pittsburgh region, or *Fifth District*, was commenced by Mr. McKinney, and continued in following years by Dr. Jackson, Mr. McKinley, and other assistants of the corps.

The Second Geological Survey of Pennsylvania was organized in 1874. In 1875, Prof. J. J. Stevenson, assisted by Mr. I. C. White, made a complete detailed survey of Greene, Washington, and Southern Allegheny counties. In 1876, Prof. Stevenson made a similar survey of Fayette and Westmoreland, (west of Chestnut Ridge,) and of Eastern Allegheny. In the same year Prof. White surveyed Beaver, South Butler and Western Allegheny. In 1877 Prof. Stevenson surveyed the Ligonier Valley; Prof. White, Lawrence county; and Mr. W. G. Platt, Indiana county. In 1878 Mr. Platt surveyed Armstrong county. The Pittsburgh Coal Region proper was thus entirely covered, and its geology described in Reports K, KK, KKK, Q, H4 and H5. A special report (L) on the Connellsville Coke district, and on the application of rock gas to iron manufacture appeared in 1876. In 1884 Mr. J. Sutton Wall's report (K4) on the mines of the Monongahela valley was published.

The present report has been prepared in deference to an Act of Legislature requiring a re-survey of the Pittsburgh Coal Region, with the end in view of bringing together, in one volume, all the facts gathered from different sources, bearing upon this region. Work was commenced in July, 1885, with an unsuccessful attempt to obtain some expression of opinion from the various operators of the district as to what special features of the district required attention. A large number of the mines were entirely closed down in the fall of that year by reason of the great labor strike, and investigations were carried on with the greatest difficulty and with little or no encouragement from those who should have been most interested. In the preliminary report of 1885 the special district between the two great rivers south of McKeesport was illustrated and a list of tide elevations of numerous points occupied during that season subtended.

A brief chapter suggesting certain changes in the structural features of the region was likewise incorporated in that report and the subject illustrated by a map showing the rise and fall of the Pittsburgh coal bed by means of contour lines.

Demands upon my time elsewhere in the State and the necessity of preparing matter for the Annual Report of 1885, during the continuance of good field weather, brought the working season to a close early in the year. When the work was renewed in 1886, the gradual improvement of business and the partial settlement of labor troubles, led to renewed activity in the district and the reopening of many mines ; but at the same time, interest in the work of the survey became more widespread, and in endeavoring to meet the demands for an examination of the Chartiers Valley and Panhandle districts, it was not possible to re-visit many mines along the Monongahela and Youghiogheny which had been shut up and deserted during 1885.

Whatever incompleteness this may have caused in my personal report upon such a large district, I trust will be offset by the free and frequent use I have made of the reports of my predecessors in the field whose examinations were more limited, time more extended and opportunities perhaps greater than my own ; and for this use of their valuable work I wish here to make the fullest acknowledgment. To Prof. Stevenson, whose wonderfully painstaking and accurate reports upon the stratigraphical geology of the whole region under discussion, has rendered almost necessary the reproduction of many of his descriptions, I am especially indebted.

My special attention, in a field already so well gone over and described, was directed to the principal commercial coal of the region—the *Pittsburgh Bed*—to a correct delineation of its outcrop; briefly, the historical and statistical facts bearing upon its development; the structural lines affecting its position for mining; the stratigraphical features of the coal measure systems above and below it, and the methods most in use for mining and transporting its product to market.

All these points will be treated of in the successive chapters of this report, supplemented by a description of the township geology of the various counties wherein the Pittsburgh coal bed is exposed or within easy access.

In this part of the report, Allegheny county naturally merits some little preëminence and detailed description. For though, perhaps, the most important and industrially active county in the western part of the State, its citizens have hitherto been compelled to look through several volumes of the Survey reports in order to obtain any exposition of its geology, structure, or commercial aspects.

In the collection of data for the construction of an entirely new map of South-Western Pennsylvania, I was given the most cordial and ready assistance by the various transportation companies of the region; the mining and civil engineers and coal companies supplementing this material with their private notes, until I have been able to present, for the first time, I believe, a map of that portion of the State, fairly accurate at least as to its general boundaries. Such assistance rendered came from so many sources that it is not practical for me to render any but this most general acknowledgment.

In the preparation of this map from a multitude of different pieces, on different scales, and sometimes from conflicting authorities, too much credit cannot be given to the Messrs. Harden and Adachi of the Survey, who have worked laboriously for whatever measure of satisfaction this map may call forth. Upon it I have shown, by means of separate tints, the approximate extent of the various rock groups comprised in this district, supplementing my own surveys with the work of the geologists engaged at different times in this and adjoining districts.

The elevations of various openings in the *Pittsburgh coal bed*, all reduced to tide level, have also been placed on the map, as affording ready means for comparison of levels in different parts of the field and for an elucidation of the structure.

Most of these levels have been determined by the barometer, and are more than usually correct by reason of the frequent checks afforded by the numerous railroad lines traversing the district, and from verification, wherever possible, with mine surveys along the outcrop of the bed.

The levels of the Westmoreland Coal Company, between the Pennsylvania railroad and the Youghiogheny river and along the north-eastern extension of the Irwin basin, were kindly placed at my disposal by the company, and have been run by spirit level.

They have served to emphasize the discrepancies already referred to in the report of 1885 along the line of the Baltimore and Ohio railroad, which company has not been able to submit any revision of the table published (with those of other railroad lines) in the report for that year.

In conclusion, I wish to acknowledge the assistance rendered by Messrs. A. N. Humphreys and Selwyn Taylor for their memoirs upon the mining methods of the Westmoreland and Pittsburgh district, which appear, to a great extent, as submitted, in Chapter X.

CHAPTER II.

History and Statistics.

The earliest record of the beginning of the coal mining industry in this part of the State is the year 1760, when Captain Thomas Hutchins, who visited *Fort Pitt* (now Pittsburgh) in July of that year, found a coal mine opened on the opposite side of the Monongahela river, for the use of the resident garrison. It is true that one year earlier, in 1759, mention of the discovery of coal along Redstone creek and Coal run, on the upper Monongahela, near Brownsville, was made by Col. James Burd, who also claims to have burned about a bushel of it on his camp fire, while engaged in cutting Braddock's road from a point east of Uniontown to the Monongahela river, near Brownsville. But the first mention of coal being *mined* is the one first referred to.

And in 1766 Rev. Charles Beatty, upon a visit to the spot, also mentions the Coal Hill deposit, where it "had been burning almost a twelve-month entirely under ground."

In November, 1768, the Penn proprietaries purchased from the chiefs of the Six Nations the whole of the bituminous coal field of Pennsylvania, except that portion which lies northward of Kittanning, which was not purchased until 1784.

At this time, privileges to mine coal in Coal Hill were sold to all comers at £30 a lot.

The chronicler* goes on to say that:

> "From this time the demand for coal, not only for domestic but for manufacturing purposes, increased rapidly. Various minor industries, such as are common to frontier towns, and especially to one situated as was Pittsburgh, were established. The first steam engine was brought to the town in 1794; salt was produced in the neighborhood in considerable quantities, coal being used in evaporation; coal-pits were opened on the Pittsburgh side of the river, at Minersville (Herron's Hill) among other places, and in 1797 Craig & O'Hara located their glass works, the first west of the mountains, just opposite the

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*Mr. Jos. D. Weeks in the Centennial number of the Pittsburgh *Commercial Gazette*, Thursday, July 29, 1886.

Point, on the South Side, this location having been selected because coal could be obtained just at the works, a proposed site on the Allegheny side of the river having been abandoned because digging failed to show coal.

"In the first twenty years of the new century, the new industry assumed new importance. Steam engines were introduced into manufacturing; industries requiring large amounts of coal were established, and the population that was attracted to this rapidly-growing town found coal so cheap that it was used with a freedom in the household scarcely known in other and less favored localities.

" In Cramer's *Navigator* for 1814 is a most interesting statement regarding the coal and coal-banks of Pittsburgh at that time. It says:

" 'This place has long been celebrated for its coal-banks, and both as to quantity and quality it is not exceeded by any part of America, or, perhaps, of the world. It is in fact in general use in all private houses and in the extensive manufactories established through the town. Coal is found in all the hills around this place for ten miles at least, and in such abundance that it may almost be considered the substratum of the whole country. The mines or pits which supply the town are not further than from one to three miles distant, between the rivers. Until within a few years no coals were brought across the Monongahela, but, since the price has been advanced from the increased demand, a considerable supply is now obtained from that quarter. Little short of a million of bushels are consumed annually; the price, formerly 6 cents, has risen to 12, keeping pace with the increased price of provisions, labor, etc. Several of the manufactories have coal-pits at their very door, such as those under the Coal Hill, which saves the expense of transportation. The coal-pits on the side of the Coal Hill are about one third from the top, which is on about a level with the stratum on the opposite side of the river. There are forty or fifty pits opened, including those on both sides of the river. They are worked into the hill horizontally, the coal is wheeled to the mouth of a pit in a wheelbarrow, thrown upon a platform, and from thence loaded into wagons. After digging in some distance, rooms are formed on each side, pillars being left at intervals to support the roof. The coal is, in the first instance, separated in solid masses, the veins being generally from six to eight feet in thickness, and is afterwards broken into smaller pieces for the purpose of transportation. A laborer is able to dig upwards of 100 bushels per day.'

" We cannot follow the growth of Pittsburgh and its manufactories in order to show how rapidly the consumption of coal increased. Rolling-mills, nail factories, foundries, machine shops, glass-works saw-mills, paper-mills, woolen factories, cotton factories, among the great industries, and the thousand and one minor trades that gather about a great town, were established here. All of these used coal for power, and many of them still larger amounts in manufacturing processes. The steamboats plying on the rivers and the salt-works made large demands upon the mines, while still greater quantities were sent down the Ohio to the lower country. It was estimated that in 1883 there were ninety steam engines in Pittsburgh, consuming 2,065,306 bushels a year; 3,600,000 bushels were consumed in families; 2,000,000 bushels in stoves, schools, and in small manufacturing; a total of 7,365,306 bushels, which, at 4 cents a bushel, was worth $306,512. In the ninety salt-works of Western Pennsylvania, 5,000,000 more bushels were used per year."

The first coal shipped from Pittsburgh was in 1803, when the *Louisiana*, of 350 tons burden, was "ballasted with stone coal, which was sold at Philadelphia for 37½ cents per bushel." This was long prior to the formation of the Monongahela Navigation Company, whose first locks, Nos. 1 and 2, were constructed in 1841.

In 1820, coal mining was commenced on a small scale at Coal Centre (Greenfield), and 10 years later, to a considerable extent at Limetown, both places on the Upper Monongahela in Washington county.

The product of these small operations, the early types of many of the small country pits of to-day, was transferred to boats, usually 68 to 79 feet long, 16 feet wide and 4½ to 5 feet deep, and hold from four to six thousand bushels of coal—cost about $100—and floated to Pittsburgh and the Ohio river cities.

In the city directory for 1837, Mr. Isaac Harris gives a list of 10 collieries working in Coal Hill, producing over five million bushels of coal from this one locality. He makes mention of the fact that "between Pittsburgh and Brownsville there are 35 to 40 coal railroads reaching into the coal region in the hills on each side of the region," bringing the total production at that period up to nearly twelve million bushels, which he estimated to be worth five cents a bushel.

Such were the beginnings of the coal trade and its commercial effects during the first three decades of the city of Pittsburgh's existence. It is needless to pursue this detailed statement of the steady growth in the shipments of coal, which now and for several years past have averaged 75,000,000 bushels *by boat alone.*

The beginning of the construction of the Mohongahela Navigation Company's system of locks in 1841 and their completion to Brownsville in 1844, incited a wonderful development of this industry, which has been steadily increasing through every decade, notwithstanding the competition of other regions and the use of other fields.

This ratio of increase and the natural fluctuations of the same, will appear more clearly in the statement of the tonnage of the Navigation Co. since 1844, which will presently appear in this report.

The completion of the Youghiogheny slackwater system in 1850, (though now abandoned); the construction of various lines into all parts of the region, and the recent equipment of the large Davis Island dam below Pittsburgh, have all combined to swell these totals and quicken the development of this unrivaled coal field.

Most of the river trade to-day is confined to the first four pools, comparatively little tonnage originating south of Brownsville. But it is in the harbor of Pittsburgh that the immense coal fleets are made up, from which a single steamer often tows a cargo of 200,000 bushels and sometimes as much as 600,000 bushels, to the lower Ohio cities.

Geographical position, topography, etc.

The *Pittsburgh coal region*, of which Pittsburgh is the commercial if not the actual centre, comprises parts of five counties in south-western Pennsylvania—viz: Allegheny, Washington, Greene, Westmoreland and Fayette. As already stated in the preliminary report on this region in 1885, it is not possible to define geographical boundaries for this district, for none such exist.

It is equally impracticable to limit it by its geological features; for the location of the different coal basins along north east and southwest belts of country, at angles to the geographical points of the compass and the great transporting mediums of the district, makes them only in part tributary to the Pittsburgh trade; while other portions of the different troughs seek outlets for their products in entirely distinct, though adjoining parts of the same field. Thus, for illustration, the coal of the Lisbon basin, which crosses the Monongahela at Rice's Landing; the Youghiogheny at Port Royal; and the Pennsylvania railroad near Irwin's,—though occurring *geologically* in the same basin, is *commercially* widely distributed from these three points to totally different markets and by three distinct agents of transportation. A comparatively small percentage of the business of the two great mining companies on the Penn'a

R. R.—the *Westmoreland* and *Penn Coal Companies*—goes west at all, and can hardly be considered as part of the output of the Pittsburgh district, or treated of in a report dealing with the *Pittsburgh Coal Region.*

And yet the character of the coal (Pittsburgh bed); the methods of mining, and geological relationships, all tend to place their product, side by side, with that of the Youghiogheny and Monongahela river, which all passes directly to Pittsburgh, and is from there distributed through the various channels of trade.

Broadly speaking, it would perhaps be advisable to designate the *Pittsburgh Coal Region* as all that south-western portion of the State lying east and north of the West Virginia State lines; west of the Fayette and Blairsville (Indiana) anticlinals and south of the Kiskiminetas and the Butler and Beaver county lines. Such a district would be situated between meridians 2° 30′ and 3° 30′ west from Washington and north parallels of 39° 45′ and 40° 45′. And it would be intended to comprise all portions of the south-west corner of the State carrying the *Pittsburgh coal bed* under water level or in the hill tops, *excepting* what is popularly known as the *Connellsville coking coal basin*, extending from the neighborhood of Uniontown on the south-west, through Connellsville, Mt. Pleasant and Latrobe to Blairsville on the Kiskiminetas or Conemaugh river.

But manifestly the *Greensburg trough*—a distinct basin in itself, and of growing importance—and a large part of the Lisbon basin north east of the Youghiogheny have no more title to recognition, from a commercial standpoint, in a discussion of the *Pittsburgh district* than the basins further east.

And in like manner much of the territory west from Pittsburgh shares, to but a limited extent, in the review of a region so defined.

It has, therefore been thought best to review *generally* that portion of the field occupied by Allegheny, Washington and Greene counties, with portions of western Westmoreland and Fayette tributary to the Pittsburgh trade, and *specifically* treat in some detail those portions of this territory which have the *Pittsburgh bed* exposed, accessible and developed; for it is to this great coal bed alone that the region owes its present preëminence as a coal producing district , and upon whose development in the past it has laid the solid foundation for its wealth and prosperity as a manufacturing centre.

Pittsburgh itself can hardly be geographically described as occupying the centre of the coal producing portion of the area just defined as the *Pittsburgh Coal Region;* but from its preëminence as the centre of extensive river and railway systems, and the controlling clearing house of the regions' wealth, it can be certainly regarded as the granary of the district, the exposition of its progress, and the chosen avenue for the distribution of its many products.

Situated at the junction of two great rivers—the Allegheny and Monongahela—whose combined drainage basin is estimated at nearly 20,000 square miles, the natural claims for precedence over the other important towns of the district, more nearly in the heart of the coal-producing area, become manifest.

Through her internal system of river navigation, she has access to 18 States for her products. She is but 150 miles from the great chain of lakes to the north-west, and but a day's ride (300-400 miles) from the large cities of the eastern seaboard. Here, then, is potent reason for designating Pittsburgh as the chief commercial centre in the western part of the State, and from within her limits, rivers, streams, and railroads diverge to carry her manufactures and natural products to far distant parts of the whole country.

The estimated population, within the boundaries of Pittsburgh and Allegheny City in 1886, is about 300,000. Though the topography in the immediate vicinity of the three great rivers meeting here is seemingly somewhat detrimental to the growth of a great city, the high bluffs cut out by erosion and flanking the city on three sides, give way, once their summits are scaled, to a beautifully rolling and healthy country, with fertile soil, and ample room for a growing community.

The magnificent system of natural transportation, furnished through the great rivers of the district, is amply augmented by a most excellent system of railroads, all centering in Pittsburgh and Allegheny, and giving the twin cities a far-reaching influence over the surrounding counties, besides a most perfect communication with the outside world generally. Nature indeed seems to have lavished her choicest gifts upon this portion of south-western Pennsylvania, giving much force and character to the industrial growth of the region.

Necessarily Pittsburgh and Allegheny, situated in the very heart of this busy community, and bound to it by all the links that Nature and Science have afforded, feel every impulse of activity given forth by the many mines, mills, furnaces, and factories which dot the district and receive the attention of its people.

River Interests.

Perhaps, after all, the first cause of the distinguished industrial position attained by this portion of the State lies in the unrivaled water navigation it enjoys.

Here again Nature's gifts have been improved by man; and constant agitation, not altogether barren of results, looks to still greater improvement in these water highways. As it is, this community enjoys an extent and perfection of inland navigation perhaps without a parallel in the world.

The system of slack-water dams along the Monongahela river from Pittsburgh to the West Virginia line has rendered that stream navigable for its entire distance, besides backing water a considerable distance up its main tributary—the *Youghiogheny river*—whose dams have been unfortunately allowed to disappear.

The Allegheny river is naturally navigable for some distance, while the proposed Herr's Island dam will create additional harborage for some distance north of Pittsburgh. The Kiskiminetas is unnavigable, the old State canal having been vacated.

The Davis Island dam, finished in 1885, and built across the Ohio river a short distance below Pittsburgh "at a cost of $800,000, is estimated to furnish a pool 7′ deep of 1.62 square miles, sufficient to harbor over 12,000 steamboats and barges. The lock length is 600 feet, with a width of 110 feet. * * The height of dam, from sill to crest, is 12 feet. Backwater will extend to the foot of the first dam in the Monongahela river, and to Garrison Ripple on the Allegheny, in front of the United States Arsenal."

The survey upon which organization was formed for the construction of slack-water navigation by the Monongahela Navigation Company, was made in 1838, under the direction of the late W. Milnor Roberts, with Nathan McDowell and Robert W. Clarke as assistants.

From Pittsburgh to Brownsville was found to be 55½ miles, nearly, and the ascent a little over 33½ feet; from Brownsville to the Virginia line a little over 35 miles, ascent 41 feet—totals 90½ miles, and 74½ feet.

It was finally found that seven dams would suffice to bring about all desired improvements. Of this number, four are located below Brownsville and three above.

Of the former set, the first three have 8-foot lifts, and Dam No. 4 ten feet. The last three, above Brownsville, have respectively lifts of 13½, 14, and 16 feet.

The location of these dams is as follows:

No. 1, a mile above Smithfield Street bridge, at Pittsburgh.

No. 2, at Braddocks Upper Ripple, 10 miles above No. 1.

No. 3, at Watson's run, 2 miles above Elizabeth.

No. 4, Frey's shoals, 15 miles above Lock No. 3 and 15½ miles below Brownsville.

No. 5, Watkins' bar, 2 miles above Brownsville.

No. 6, Rice's Landing, 10 miles further up.

No. 7, Jacob's creek lower riffle, 2 miles below Greensboro'.

From Pittsburgh to Brownsville the ascent of the river is but a little *over seven inches per mile;* from Brownsville to the State line it is *over fourteen inches*, and from the State line to Morgantown in W. Va.—about 11 miles—it is *over seventeen inches per mile*, showing that the plane of its ascent increases in direct proportion to the contraction of its channel towards its sources.

The following description of the method of constructing these dams is of interest:*

The dams are constructed of logs, squaring at least a foot, built up perpendicularly from the bed of the river to near the water level, when they begin to slope on both sides, to the comb, after the manner of an old-time log cabin. They are tied together by cross timbers parallel with the line of the river, bolted to the longitudinal timbers so as to form a net-work, with interstices of seven by nine feet, filled with stone. Their breadth at the base is about 65 feet; their depth below the slopes, as originally built, is from three to six feet, though, by reason of breaches, they are now much deeper in places. Dams 1 and 2 run straight across the river. No. 3 is in three straight lines of unequal length—the middle one 280 feet, the other two aggregating about 420 feet—the middle one being at right angles with the channel, the other sloping from it downwards to the shores, about 22 feet from the line of the middle part. Dam No. 4 is a segment of a circle—about 605 feet in length—curves up stream, having a versed sine of 15 feet. Dams 5 and 6 are also segments of a circle, with the convex sides upwards, and are each about 600 feet long. These, by reason of their increased height, 13½ and 14 feet, have the longest slopes on the lower sides. The others slope about equally above and below—from three to four feet of slope to one foot of rise. They are sheeted above with double courses of oak plank, closely laid, five inches thick, spiked to the timbers, and covered with gravel. The sheeting below is of heavy oak timbers, of spars, flattened to eight inches, and spiked to the crib timbers. The dams are further secured at their ends by high, strong cribs filled with stone, and above by double courses of heavy sheet piles, driven vertically into the bed of the river to such depth as to be secure anchorage to the entire structure. In some cases, since their original construction, piles have been driven in below, vertically, and above, slopingly. Dam No. 7 will be on rock, and will be otherwise fastened.

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*History of the Monongahela Navigation Company.

The locks first built in dams 1 and 2, also those in Nos. 3 and 4, are 100 by 50 feet in the chambers, between the points or mitres of the gates and side walls. The entire length of the walls is 252 feet, and their height about 25 feet. They are 10 and 12 feet thick, built of heavy blocks of dressed stone, laid in hydraulic cement and securely clamped. Except those of No. 1 and 6, which have rock bases, they are built upon heavy oak timber deeply laid and covered with heavy oak plank.

Each of the old locks contains over 5,300 perches of stone. The new ones have proportionately more. These are 250 feet by 56 feet in the chambers, built in other respects as were the old ones. The locks in Nos. 5 and 6* are of the size in the old ones in Nos. 1 and 2. All the locks are guarded by substantial cribs and fenders, above, below, and at their sides. They are constructed so as to allow at least five feet of water above the mitre sills, against which the gates close at their lower entrances. The locks are floored with heavy longitudinal timbers, covered with heavy plank, well spiked.

* * * Since the works were first put in operation, experience and skill have taught great improvements in the modes of emptying and filling the locks, and of working the gates. The objects were speed, ease and security. At first the water was let in and discharged by sluices in the lock walls and floors of the chambers, and the gates were worked by rollers at their bottoms, running upon arcs of iron railways, and moved by sheaves, chains and crabs. The water is now let in and out by series of wicket gates at the lower ends of the gates, fitting closely and worked by rods and levers. The gates—their tops working in wing journals, securely fastened to the walls, and their feet on pivots—are worked by capstans on the walls, with chains and heavy wooden spars or levers.

The company met with many vicissitudes since their organization, such as floods, failure of subscriptions, etc., which culminated about 1842, when the whole project became a "mortification to its friends and projectors, and a nuisance to the navigation."

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*No. 7 had not yet been structed at time of writing this history.

In 1847, the construction account had swelled to $517,225, and only the first four dams had been built. At the end of 1847, the company was $270,000 in debt. But before the work had been completed to Brownsville, the Balt. & Ohio Railroad had been made to Cumberland, 75 miles distant, over a fine road, on which were "first class accommodations for man and beast." The Pennsylvania Railroad did not reach Pittsburgh until 1852. Here were eight years of a glorious harvest for the Slackwater, and the Eastern Division of the National road. It taxed the road's capacities to the utmost extent. It was literally crowded with stage coaches and wagons. In 1850, the Navigation carried 18,379 stage passengers, and in each of the three preceding years a greater number.

From 1845 to 1847, the revenues had almost doubled. Notwithstanding that the tolls from freights and passengers continued about the same for many years, such was the rapid increase of the coal trade, that at the end of 1853, a large amount of the indebtedness was paid; and, but for new debts incurred in 1850, for some additional rights ($2,000), and a second lock at Dam No. 1 ($56,800), and in 1853-'4, another lock at Dam No. 2, costing about $50,000, rendered necessary to accommodate the increased coal trade, and the extension above Brownsville, the company could have been free from debt. The toll on coal over the entire Navigation was $2.91 per 1,000 bushels. At present the rate for similar service between Brownsville and Pittsburgh is 90 cents per 1,000 bushels for each lock, or $3.60 for the entire distance. The stock was doubled in 1848 for the purpose of carrying out improvements above Brownsville, and in 1854 contracts were let for constructing Dams Nos. 5 and 6. Their cost, including the raising of Dam No. 4, was nearly $200,000.

When the Slackwater of the Youghiogheny was being constructed, large expectations were indulged in as to its auxiliary influence. They were not realized. Whether from defectiveness of construction, or from miscalculation

254603

of the power of the floods and ice in that river, the locks and dams upon it—two carrying the Navigation to West Newton, eighteen miles—were of short duration. They lasted for only fourteen years, with long intervals of uselessness for lack of repair; and the great ice flood of January, 1865, put an end to them. They are now in ruin, and the charter of the company extinct.

In a large measure, the shipments of coal from the Monongahela district are but the totals of tonnage shown by the Monongahela Navigation Co. It is true that no small percentage of the business of to-day is carried away by the various railroads which extend through this region. It is difficult to get at the business of these lines of traffic; owing first to the difficulty of geographically defining the limits of the Pittsburgh coal region; and second, to the difficulty of obtaining such separate statistics from the various companies, with such accuracy as would furnish a close approximation to the truth concerning the immense tonnage of this region.

In view of these facts the following table, kindly furnished by the Monongahela Navigation Company, will be of great interest and value as giving, 1st, an accurate statement of the vast capacity of the slack-water navigation existing along the Monongahela river; 2nd. A concise and yet detailed account of the business of the various pools, and the rate of increase in shipments at different periods of time, and finally, 3rd, a clear exposition of the productiveness of this splendid coal field, with a full understanding that the totals represent solely the river trade, or that carried through the locks of the Navigation Company, and entirely distinct from the tonnage of the various railroads.

No account is taken of passengers and general merchandise business.

Shipments of coal through the Monongahela Navigation Company's locks, since November 11, 1844.

YEAR.	POOLS.					Totals in bushels.
	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	
1844,	737,150	. . . .	. .	. .	. . . .	737,150
1845,	2,527,879	1,328,604	314,342	434,360	. . . .	4,605.185
1846,	3,167,528	3,091,639	767,708	752,036	. . . .	7,778,911
1847,	3,377,703	4,188,258	1,227,201	851,965	. . . .	9,645,127
1848,	3,536,761	3,986,643	1,436,666	859,291	. . . .	9,819,361
1849,	2,944,044	4,420,347	1,434,723	909,393	. . . .	9,708,507
1850,	3,988,200	5,540,470	1,862,548	906,749	. . .	12,297,967
1851,	4,105,624	5,846,168	1,769,302	800,134	. . . .	12,521,228
1852,	4,797,704	7,188,539	1,736,622	907,976	. . . .	14,630.841
1853,	5,372,732	7,325,062	2,015.250	1,003,323	. . . .	15,716,367
1854,	4,756,263	9,251,532	2,006,633	1,317,518	. . . .	17,331,946
1855,	6,829,282	11,485,072	2,633,555	1,286,100	. . . .	22,234,009
†1856,	3.910,978	3,213,740	1,031,613	427,764	. . .	8,584,095
1857,	7,859,775	17,255,226	2,731,959	1,126,636	. . . .	28,973,596
1858,	7,082,600	15,143,868	2,500,025	970,176	. . . .	25,696,669
1859,	7,591,500	15,732,845	3,469,137	1,493,189	. . . .	28,286,671
1860,	10,550,384	20,861.200	4,878,704	1,603,344	54,100	37,947,732
1861,	4,483,717	11,495,900	3,595,705	1,290,400	. . .	20,865,722
1862,	4,801,856	10,094,100	2,739,500	948,500	. . . .	18,583,956
1863,	5,935,392	14,182,600	4,481,810	1,844,450	. . . .	26,444,252
1864,	7,202,175	18,415,700	6,549,700	2,903,342	. . . .	35,070,917
1865,	8,013,692	19,132,400	8,915,600	3,402,200	58,900	39,522,792
1866,	8,813,200	23,064,500	7,577,600	3,059,100	100,900	42,615,300
1867,	6,139,200	16,075,200	5,555,200	2,274,900	28,200	30,072,700
1868,	8,796,400	23,802,700	7,622,600	5,072,500	9,800	45,301,000
1869,	8,868,900	29,129,800	8,988,400	5,501,900	23,600	52,512,600
1870,	8,070,700	32,132,000	10,012,400	7.361,300	20,000	57,596,400
1871,	6,966,200	27,348,700	8,300,400	6,006,000	. . . .	48,621,300
1872,	8,989,000	28,614,500	9,176,000	7,429,300	. . . .	54,208,800
1873,	7,781,600	27,316,150	9,710,645	10,305,100	. . . .	55,113,495
1874,	9,113,500	33,516,700	11,440,800	11,810,700	. . . .	65,881,700
1875,	9,200,300	31,729,900	7,911,900	12,566,900	. . . .	61,409,000
1876,	8,913,300	28,489,300	11,367,200	13,625,200	. . . .	62,395,000
1877,	12,452,700	34,763,100	11,056,800	14,430,200	. . . .	72,702,800
1878,	12,237,465	34,263,450	11,336,100	12,101,240	. . . .	69,938,255
1879,	9,526,500	29,686,400	9,147,700	13,654,700	. . . .	62,015.300
1880,	10,319,100	40,443,450	15,306,300	17,979,500	. . .	84,048,350
1881,	8,713,260	47,944,500	14,148,800	15,448,100	. . . .	86,254,660
1882,	11,343,700	49,888,700	18,606,700	21,595,600	. . .	101,434,700
1883,	11,624,500	58,208,300	18,151,400	20,503,600	. . . .	108,487,800
1884,	10,482,100	31,218,000	17,619,200	19.920,800	29,000	79,269,100
1885,	11,462,450	34,219,200	15,677,300	21,085,100	15,000	82,459,050
Totals in bushels,	303,387,014	871,034,463	286,811,748	267,770,586	336,500	1,729,340,311
*Totals in tons,	11,535,628	33,119,181	10,905,388	10,181,391	12,795	65,754,384

†Disastrous flood.
*Estimating 1 ton equal to 26.3 bushels.

Allowing an average of about 100,000 bushels of coal to the acre, these totals represent a depletion of nearly 17,300 acres, tributary to the Monongahela Navigation Co's. slackwater system, not estimating the additional tonnage of mines shipping solely by railroad or the product of the many country pits contiguous. The slight tonnage from Pool No. 5 is rather noticeable, for though this pool is short, and the Pittsburgh coal partly under water level, the quality of the coal is excellent; the bed holds a splendid thickness, and is readily accessible. It is true, however, that all the coal south of Brownsville becomes much softer and therefore is less desirable for shipment to distant points. For 13 years (1871-1884) there have been no shipments from this pool by river, and in 1884-85 the total amount shipped is quite insignificant—only *44,000 bushels* (*1673 tons.*)

A comparison of the returns of the various pools shows some interesting facts, fairly indicative of the coal trade of the region during the past half century.

The magnitude of tonnage in 1885 as compared with 1845 is of course the most striking feature of the table. A trifle over 4½ millions bushels were shipped from the four pools then in operation, as against 80 odd millions of bushels in 1885.

And this contrast will be more striking if we compare the early output with that reached in 1883 (over one hundred millions)—prior to the general introduction of natural gas.

Between 1845 and 1885 there is an average increased shipment shown of *about* 2 million bushels per year. This average increase, however, is not indicated by the yearly returns of the various pools. For instance, in 1855 the total was 22 millions (dealing in round numbers); and in the following year only 8½ millions. But the decrease must have been almost entirely due to the disastrous flood of '56, which swept away 200 feet of dam No. 2; for in the four succeeding years, the tonnage was steadily increased until 1860, when it amounted to 38 million bushels.

During the period of the war, the output varied considerably from year to year; but barring another serious setback in 1867—another year of disaster from water and ice—when the decrease was over 10 million bushels, the average gain was steadily maintained until 1883 which records the zenith of shipments, *108 million bushels or 41 million tons.*

Since that time, the depression of the coal mining industry in the Pittsburgh district, due to the general application of natural gas for domestic as well as industrial purposes has caused a curtailment of over 20 million tons in the yearly production.

That the displacement of coal by the use of the new fuel, which is rapidly growing into favor, may be more thoroughly understood, a little digression from the discussion of the Monongahela Navigation table seems warranted, especially as this new factor in the economics of the region has largely militated against the increased development of the coal industries.

Mr. T. A. Gillespie, of the Philadelphia Company, in the *American Manufacturer* of August 13, '86, estimates the daily displacement of coal by natural gas in Pittsburgh alone at 20,000 tons and estimates that there were from 15,000 to 18,000 tons of coal used in Pittsburgh at the time gas was first introduced. A bushel of this coal weighs $85\frac{3}{25}$ lbs., and as there are $26\frac{6}{19}$ bushels to the ton, 18,000 tons of coal is equivalent to 473,682 bushels.

Mr. George H. Thurston in his book on "Pittsburgh's Progress, Industries, and Resources" reviews the increasing favor of this fuel somewhat as follows:

"Although natural gas was first practically applied in Pittsburgh in 1875-6, * * * yet its general adoption as the fuel of the future dates back only to July, 1884, the formation of the Philadelphia Company.

At this date (1886) 3000 families, 34 iron and steel mills, 60 glass factories, and 300 smaller factories and hotels, are using for their fuel gas obtained and distributed through the pipes of this one company,* of which there is at present laid 336 miles. Of this, 66 miles are within the city of Pittsburgh. Of this pipe 50,000 feet, or nearly 10 miles, is 24 inches in diameter; 37,000 feet, or over 7 miles, 20 inches in diameter; 29,000 feet, or nearly 6 miles, 16 inches in diameter; 59,000 feet, or over 11 miles, 18 inches in diameter; about 14 miles, 8 inches in diameter. * * * Already, it is claimed, there has been effected a saving of 40 per cent. in the fuel cost of manufacturing.

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* These estimates of course, do not take into account the business of various other gas companies, which would largely swell the figures given by Mr. Thurston.

To return once more to the Navigation Company's table, it becomes apparent that the general business condition of the country has had an important bearing upon the production totals, *except* during the latter years of natural gas consumption. From 1868, when the output was 45 millions, the statistics record an uninterrupted and steady increase annually, except in years of financial trouble, or more correctly speaking, when the effects of those troubles were being felt throughout the country.

Thus the heavy decreases since that period were in the years 1871, '78, and '84.

On the same principle the largest relative outputs were made in the years of prosperity and business activity, 1870, '77, and '83. The total output in these 40 years, was *17 hundred millions of bushels*, moved by water alone.

Of this number 50 per cent. has been furnished by Pool No. 2. The output of this pool is by far the most important factor in the statistics, and its record is practically the same as that furnished by all together. In 1845 its output was *one-half* of that furnished by No. 1; in 1855 it was twice as much, and in 1866 nearly three times as much: in 1880 it was four times as much; in 1883 five times as much. But as the loss from the entire region during the last 3 years has come solely from this No. 2 pool, the ratio in 1885, as compared with No. 1, is again down to three times the latter's production.

The record of Pool No. 1 has been the most regular of all. Starting in 1845, with an output of 2½ millions, it increased gradually until 1880, when 10 million bushels came from within its boundaries. This has been about its average production ever since, never getting higher than 12½ millions (1877) nor below 5 millions during the past 25 years. It has furnished since its infancy just about one fifth or 20 per cent. of the entire shipments.

Nothing but the average increase is noticeable in the records of Pool No. 3 until 1870, when its production amounted to 10 million bushels, and for the first time exceeded the output of No. 1.

The following 10 years, from 1870 to 1880, the output of these two pools was almost identical; but since 1880 the production has all favored No. 3 pool, no doubt largely curtailed and shipped by the railroad and not appearing therefore in the table.

In 1883 its production was quite double that of 1879; it has furnished about 17 per cent. of the entire production, and this is a fair average during the past 15 years.

The same comparisons can be made with the progress of Pool No. 4 relative to No. 3 as has just been made between Nos. 3 and 1. In fact the *ratio of gain* in this pool has been greater than in any of the others, as its production now is more than 30 times as great as when it was newly built, and fully 3 times as great as in 1870. The other pools show only partial gains during the latter period.

Its production last year (1885) was 25 per cent. of the total, as against 18 per cent. for No. 3, 12 per cent. for No. 1, and 42 per cent. for No. 2. In its total output, however, it has furnished less coal than any of the other pools, and about 15 per cent. of the whole. But this fact is due largely to curtailment from 1850 to 1869, when its net increase was very small.

During this period the severe flood of 1865 took place, obliterating the Youghiogheny river works (which have never been rebuilt) and damaging Lock No. 4. Judging, therefore, from the statistics, as well as from the well known depletion of a large part of the "river coal" in the lower pools, it would seem that No. 4 promises to be the large producer in the future, once that its coal is firmly established, and that No. 5 will in a measure come in for its share of increase.

Nos. 1 and 2 have fairly reached their limits as producers, while No. 3 will do better in the future.

Since 1873 the shipments of coke through the locks of the Navigation Company have amounted to 54,377,816 bushels, up to 1886. The following tabular statement was also furnished by the Monongahela Navigation Company:

Coke Shipments from the Monongahela River.

YEARS.	Pool No. 1.	Pool No. 2.	Pool No. 6.	Total.
				Bushels.
1873,	. . . . . .	3,163,500	. . . . . .	3,163,500
1874,	. . . . . .	1,939,500	. . . . . .	1,939,500
1875,	. . . . . .	2,298,500	. . . . . .	2,298,500
1876,	. .	6,086,000	. . . . . .	6,086,000
1877,	1,829,668	4,948,450	. .	6,778,118
1878,	1,921,300	4,680,200	285,500	6,887,000
1879,	914,600	2,507,600	150,500	3,572,700
1880,	2,063,500	2,871,800	393,500	5,328,800
1881,	134,500	3,330,000	316,200	3,780,700
1882,	1,109,600	3,524,000	100,000	4,733,600
1883,	1,201,589	2,706,000	. . . . . .	3,907,589
1884,	492,752	1,945,000	. . . . . .	2,437,752
1885,	966,057	2,498,000	. . . . . .	3,464,057
	10,633,566	42,498,550	1,245,700	54,377,816

The totals shown in the first and second columns, from Pools Nos. 1 and 2, are mainly shipments by railroad from the Connellsville basin to points in those pools and reloaded into barges for distribution in the south-west. The shipments from Pool No. 6 have altogether ceased, owing to the abandonment of ovens there.

By this system of improvement, millions of tons of coal, coke, iron, and general merchandise have found their way to the outside world since 1844.

The Pittsburgh steamboat is a specially constructed craft, designed to navigate these comparatively narrow and shallow rivers. The transport service or "towing" of these steamers is quite unique, and as a consequence, Pittsburgh counts steamboat-building a leading feature of her many industries.

The river trade originating in this district requires from 125 to 150 of these steamboats, some of them costing as high as $100,000.

They are perhaps more largely used in the transportation of coal than anything else. Several thousand barges and coal boats are owned by the different mining companies along the rivers, and used in the transportation of their coal to the Mississippi Valley. By lashing these boats and barges firmly together in fleets to the front of the steamboat, cargoes of 20,000 tons can be taken by a single vessel, and it is surprising how readily this immense fleet can be moved.

Voyages of 4,000 miles are quite common, and the farthest recorded trip of a Pittsburgh steamer is to Cow Island, on the Upper Missouri, 4,300 miles distant.

The Chamber of Commerce report for 1884 states that there are no records, by public authority, of the boats and flats used in the river trade. The tonnage of Pittsburgh embraces at least 2,000 barges, 1,200 boats and 900 "flats," and their money value is in the neighborhood of seven millions of dollars, which, added to the steam fleet, makes a total investment of $9,740,000. The estimate is a moderate one, since we have included among "barges" what are termed "model barges." These have a hull modeled like that of a Western steamboat and a continuous inclosed deck house. Their carrying capacity is from 600 to 1,000 tons, and their cost from $8,000 to $12,000. Sixty model barges are engaged in the transportation of pig iron, steel rails, ores and general manufacture. They moved 80,000 tons from Pittsburgh to southern and western ports, bringing back over 50,000 tons during the year.

"The steamers engaged in transporting coal are constructed solely with regard to power. They are all sternwheelers, and a highly curious feature of their construction is their steering apparatus, consisting in the largest boats of five rudders, all geared together for simultaneous movement. The engines in the largest class have two cylinders of thirty inches in diameter and twelve feet stroke. They operate upon a huge iron shaft, forty feet long, and fifteen inches in diameter."

Railway System.

Three trunk lines compete to the advantage of the city in the moving of all classes of freight and merchandise. These are, 1st, the Pennsylvania railroad; 2d, the Baltimore and Ohio; 3d, the Vanderbilt system of lines.

The Pennsylvania operates not only its main line from New York, with its branches, the West Penn, the Monongahela Division, and the South Western Pennsylvania, but also the Pennsylvania Company's lines, namely; the Pittsburgh, Fort Wayne & Chicago, the Cleveland & Pittsburgh, Erie & Pittsburgh, as well as the Allegheny Valley railroad, directed to the north and north-west. Bifurcating with these at Pittsburgh is the Panhandle system, whose objective points lie west and southwest.

The Baltimore & Ohio railroad has a complete range of lines to the Lake ports *via* the Pittsburgh & Western, and Pittsburgh, Cleveland & Toledo, and another *via* the Streets Run route and Wheeling to the west and south.

The Lake Erie railroad, of the Vanderbilt system, supplies connections for the last two trunk lines named, and taps the valuable coke region by its own offshoot, the Pittsburgh, McKeesport and Youghiogheny railroad, projected still further eastwardly.

All of these roads have branch lines or "feeders" upon which a large yearly tonnage either originates or is moved in addition to what traffic directly arises from the industries of the Pittsburgh district. It is not necessary to give figures to substantiate the claims of the immense business of this section of the State. These roads would not exist unless the demands of the region which called them into existence were sufficient to maintain them successfully. Still the following extracts from the census report of 1880 will serve to give some conception of the business accruing from the several counties through which the four western arteries of the Pennsylvania railroad pass, viz: the Pittsburgh, Fort Wayne & Chicago, the Pittsburgh, Cincinnati & St. Louis, the Cleveland & Pittsburgh, and the Erie & Pittsburgh. These totals show "that along these four main branches alone there was a population of 4,268,919 inhabitants; a cash value of farms of $1,221,383,473; a cash value of farm products, annually, $189,634,059; a cash value of live stock, $113,612,804. There were also 27,764 manufacturing establishments, which consumed materials to the value of $489,771 72, and produced articles to the amount of $577,995,091."*

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*Thurston in "Pittsburgh's Progress, Industries and Resources."

No doubt a similar compilation of the resources of the lines east of and centering in Pittsburgh would be quite as striking in its results. It is estimated that the total railway tonnage of Pittsburgh per annum amounts to over twenty-two million tons, strictly local business, and not taking account of through freights.

The Coal Industry.

The wonderful prosperity of Pittsburgh as a manufacturing centre is chiefly due to its possession of a magnificent coal bed, unexcelled in quality for gas, steam and domestic purposes.

The area of the coal fields of the world is estimated at over 260,000 square miles, of which the United States contain 192,000 square miles, or 74 per cent. of the total area. The bituminous coal field of Pennsylvania, which underlies the western portion of the State, and by which Pittsburgh is surrounded, is estimated to contain 14,000 square miles. It is not, however, from the mere matter of area in square miles that the value of a coal deposit is to be estimated, nor the success of a coal trade builded upon; the essential requirements are:

1st. Good quality of the coal.

2d. Thickness and regularity of the bed, and its accessibility.

3d. Cheapness and sufficiency of transportation to market.

The Pittsburgh bed eminently combines these requirements. The commercial portion of the seam is from 5½ to 9 feet thick, and the coal, so all testimony combines to establish, is of the best bituminous quality for the generation of steam, the manufacture of gas, and for household use.

As to the second requirement, mining here requires no outlay whatever, or only an insignificant sum, since the coal seam crops out on the flanks of the hills, and the banks of the rivers, the investment being simply that for transportation facilities from mines to market. The character of the coal, too, is of such consistency as to stand the necessary handling for its being marketed withot having its value appreciably impaired by crushing, and yet permits its mining with the use of but little, if any, explosives.

The last requirement, namely, "cheapness and sufficiency of transportation to market," is almost patent from what has already been stated of the river and railway transportation. Suffice it here to say, that through her rivers, Pittsburgh has the cheapest known transport service in the world.

In 1884 the coal output of the United States was, in round numbers, 96,000,000 tons, of which quantity Pennsylvania furnished 32,000,000 tons anthracite, and 24,000,000 tons bituminous, of which bituminous coal the counties of Allegheny, Washington, Fayette and Westmoreland output 13,000,000 tons, which is 54 per cent. of the whole quantity of bituminous coal furnished by the State, and 20 per cent. of the quantity furnished by the United States.

Nearly one-third of these thirteen million of tons was turned into coke in the 12,000 coke ovens that dot the Monongahela and Youghiogheny valleys. The coal shipped east in 1884 amounted to over 1,600,000 tons, being for the largest part used in gas making. Shipped by river to Cincinnati, Louisville, Memphis, New Orleans, St. Louis, etc., were about 4,400,000 tons, the balance remaining being divided among local consumers and the Lake ports.

As a rule, all Pittsburgh coal shipped by rail a greater distance than 50 miles is for use exclusively in the manufacture of gas, while that shipped by water can be conveyed 2000 miles and used for all the different purposes of fuel as well as that of illumination. As a curiosity in the problem of cheap transportation, it may be mentioned that some of the coal shipped down the Ohio is loaded on board cars at Cincinnati and thus taken to gas works as far distant as Michigan. The gas which illumines the cities of London, Windsor and St. Catharines, in Ontario; Chicago, Detroit, East Saginaw, Port Huron, Marquette, Milwaukee, etc., is largely made from Pittsburgh coal, reshipped from Erie, Cleveland and Ashtabula.

The increase in the product of the mines from 1870 to

1884 was nearly 300 per cent., and the price of coal in these years declined more than the price of the labor necessary to produce it.

As it is Pittsburgh's relation to the *coal interest* of the district and *vice versa* rather than with her iron, glass, coke, and natural gas interests that this report mainly deals, no apology is needed for the following extracts from Prof. Lesley's paper on the "Geology of the Pittsburgh Coal Region."*

"The prime factors in the quality of the Pittsburgh coal are:—1. The low percentage of ash. 2. The small amount of pyrites. 3. The excellence of the coke made from it. The ash varies between 3 and 5 per cent., and seldom exceeds 8 per cent. The sulphur in analysis ranges at below 1 per cent. rising however occasionally to 2 or 3 per cent. in hard specimens. The coal contains from 30 to 35 per cent. of volatile matter. When coked, allowing for waste, something over one-half its weight remains as a silvery, ringing, tough, and pure coke, preferable to any coke made from the coals of the southern and western States, chiefly on account of the absence of sulphur, but partly on account of some obscurely understood internal constitution of the coke, giving that special hardness adapted for holding up the burden in a high stack furnace. * * * *

"The exhaustion of the mineral coal of the region is a practical impossibility. Every cubic yard of coal may be taken as a ton. Every square mile of a horizontal coal-bed may be said to yield a million tons to every foot of coal-bed—that is, for a ten-foot bed, 10,000,000 tons; or, allowing one-half for waste, 5,000,000 tons. The Pittsburgh region has an outspread of the Pittsburgh coal-bed 50 miles long by 50 miles wide within the limits of the State. In the northwestern part of this area, the bed is 2 or 3 feet thick, increasing in thickness eastward and southward to 6′ of good coal at Pittsburgh, 10′ up the Monongahela, and 12′ up the Youghiogheny. What the thickness of the bed may be underneath the uplands of Washington and Greene counties we now know by the new gas-wells. It maintains its thickness in that direction. An average of 8 feet for the whole region looks like a fair one. This gives 8,000,000 tons to the square mile, and there are 2500 square miles. Allowing one-half of the area to be interval, separating outcrops, we have then 10,000,000,000 tons remaining in this one coal-bed. Allowing 50 per cent. for pillars, bad mining, and waste of all kinds, we may set down its coal available for market in the future at 5,000,000,000 tons.

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* Read before the American Institute of Mining Engineers at the Pittsburgh meeting, February, 1886.

"The Pittsburgh bed was mined in 1884 to the extent of about 11,000,000 tons. At this rate the bed would last nearly five thousand years. But, of course, the rate will rise steadily. The output of the Monongahela slackwater in 1883 was double what it was ten years before. If it goes on doubling every ten years the output of the Pittsburgh bed will reach the rate of the British coal trade, say 200,000,000 in about forty years from now; and were the doubling of the rate to go on still, the bed would be exhausted in about eighty years from now. But such calculations are evidently ridiculous, especially in view of the growing competition of other coal-beds and other coal-regions of the United States. No rate of increase in the output of coal from the Pittsburgh bed will exhaust it in less time than many centuries; of this we may be perfectly sure.

"There seems to be no limit to the development of every kind of human life in the region; and while the population of the denser centers must continue to double in numbers every quarter of a century, the vast outspread of upland will always insure it comfortable sustenance, and become one of the gardens of the world, populous, prosperous, and beautiful to every eye; dependent, yet independent; a region of rural homesteads, dotted with towns and villages, with their own appliances of advanced civilization; while gradually, as the centuries elapse, collieries with deep shafts will be established in all parts of it, and the stories of Manchester, Sheffield, and Coventry, in England, will be repeated at their full value."

"Its incalculable wealth of coal, absolutely inexhaustible for several thousand years, has made Pittsburgh the envy of the business world, and is a sufficient guaranty for a destiny of inimitable magnificence in a not distant future. This region will be an empire of itself, as wealthy, as powerful as England, subsidizing all other countries for its own uses, and unassailable from all quarters of the compass."

CHAPTER III.

Structural Geology.

The structural features of the Pittsburgh Coal Region are exceedingly diversified, and by no means regular. In order to understand them most thoroughly and clearly, it was the intention to carry out the plan adopted in the Annual Report of 1885, and show by a series of contour lines, the underground position of the *Pittsburgh coal bed* in various parts of the field; its rate of rise and fall, and the general trend of the anticlinals and synclinals of the district. But in carrying the levels of this coal bed over the district generally, it was found that off the main lines of output, there was too little development to furnish data concerning the position of this bed any appreciable distance in from its outcrop. Even in the large mines of the district, inquiry developed a surprising ignorance as to the relative elevation of different parts of the workings, and until Sec. 1 of the laws relating to Bituminous Coal Mines shall have been more strenuously enforced, there is little hope of this exceedingly important information being forthcoming. It would seem as if the operators themselves would see the paramount importance of this requirement, and act speedily in a matter directly affecting the commercial success of their mines.

In the second place, the vast amount of territory south of the Ohio river and Pennsylvania railroad, wherein the *Pittsburgh coal* is deeply buried from sight, there are absolutely no reliable records of its position whatever. The mining developments are necessarily limited, and throughout Washington and Greene counties, where these remarks especially apply, and the structure is most obscure, the greatest stress should be laid upon the necessity of keeping at least a record of the depth of the *Pittsburgh coal* in the hundreds of wells that are being put down yearly for oil or gas. With such material at hand a flood of light would be let in upon this hitherto but little understood district.

The *Pittsburgh bed* is specialized, because no other stratum, above or below it, is as equally persistent and regular, and in such a region as the south-west corner of Pennsylvania, where the rock-groups thicken and thin almost without rule (see chapter IV) the Pittsburgh coal is the only reliable datum upon which to base any exemplification of the region's structure. In this part of the field the present examinations were mainly confined to the river and railroads where alone exposures of the Pittsburgh bed could be obtained, and the description of the structural features which follow, relating to other parts of the field, are mainly those of Reports K and KK. Upon the general map, an attempt has been made to indicate the approximate position of the principal anticlinal flexures of the district; but experience of similar attempts in other parts of the State has been somewhat repeated here.

The township maps of the various counties comprising the map are in most cases outrageously erroneous in general details; and after they are reduced to a uniform scale to fit within the accurate base lines afforded by railroad and river surveys, geology and geography are alike, of necessity, shifted.

Leaving out, in a discussion of the structure of the Pittsburgh Coal Region, all the several flexures in Butler and Beaver counties that might come within the limits of the general map, the arrangement and position of the anticlinal axes, as far as made out, is about as follows, proceeding from the west eastward:

1. *Bulger*	*anticlinal.*
2. *Claysville*	‘‘
3. *Brady's Bend*	‘‘
4. *Washington*	‘‘
5. *Pin Hook or Bagdad*	‘‘
6. *Roaring Run or Murraysville*	‘‘
7. *Waynesburg*	‘‘
8. *Saltsburg*	‘‘
9. *Indiana-Blairsville*	‘‘
10. *Fayette*	‘‘
11. *Chestnut Ridge*	‘‘
12. *Laurel Hill*	‘‘

Other minor anticlinal axes intervene between these larger flexures, and almost every synclinal basin in this field is divided longitudinally by such a subordinate axis, into two sub-basins.

It is moreover quite possible to reduce the number of the anticlinals by regarding some which now overlap or are shoved past each other, as parts of one fold originally.

For instance such an inference might be drawn from the position of the Brady's Bend and Washington axes; the Waynesburg and Saltsburg anticlinals and the Blairsville and Fayette flexures.

But as no such parallelism is brought out by the numerons coal levels taken during the last two seasons, it may be just as well to maintain and describe them separately.

At best they are by no means straight lines, and as a series, they show a tendency to deflect southwards after passing below the line of the Ohio River and the Penn'a R. R., from a course which they have assumed between the railroad and the Conemaugh river, along the Armstrong and Indiana line.

1. *Bulger anticlinal.*

This is an obscure and short axis, very indistinct in Allegheny county, and not too well marked in Washington. In the country north of the Ohio river, in Allegheny county, it cannot be recognized at all, the general absence of the *Pittsburgh bed* and the unsatisfactory exposures of the Barren Measure rocks there, effectually blocking any attempt to distinguish its effect. It is, in all probability, entirely absent there.

The same conditions prevail, to a considerable extent, south of the Ohio; but in Moon township it is possibly present as a gentle roll, passing in a north-east and south-west direction through Beers P. O., with the *Pittsburgh coal* on its crest, and comparative elevations of that coal would seem to extend it south-west through the Montour mine workings of the Imperial Coal Company and thence into North Fayette township, approximately with the Steubenville pike to a point a little west of the intersection of the road down Half Crown run. It reaches the Allegheny-Washington line about 1 mile south-east of North Star P. O., and touches the Panhandle railroad at Bulger station, from which it takes its name.

South-west from here it is very obscure. If extended in that direction it should be cut by Cross creek near Patterson's mill; but there and on to the West Virginia line, the rocks are all dipping to the south-east into the West Middletown–Burgettstown synclinal.

2. *The Claysville anticlinal.*

This axis, like the one just described, is insignificant in its effect upon the rock-measures through which it passes, and like it too cannot be identified in Allegheny county north of the Ohio river.

Indeed, for some distance south of the river, its place is quite as obscure, and if it can be continued this far north it should reach the river near Davis Island, passing south-west near School House No. 3 in Stowe township; through Summitville in Robinson to the vicinity of Oakdale station on the Panhandle railroad.

From here its course must be deflected slightly southwards; for following closely Robinson's creek it passes through the north-west corner of Cecil township of Washington; east of the village of Hickory in Mt. Pleasant twp.; the west fork of Chartiers creek just above the Mt. Pleasant twp. line; Brush run a short distance west of the line of Canton twp.; Buffalo creek about half-a-mile below Taylorstown and the Wheeling Division of the B. & O. R. R. near Claysville.

Its identification south-west from here has not been made out.

3. *Brady's Bend anticlinal.*

This pronounced wave is the only well defined roll through the whole of northern Allegheny, west of the river. It has been identified north-east of the district by other observers of the survey, passing through Clarion county from the Clarion river near the Jefferson county line; through

Red Bank at the confluence of the Red Bank creek and Allegheny river, and east of the great bend from which it takes its name; crosses the Butler Extension of the West Penn railroad between Saxon City and Sarvers, and through Lardintown in the S. E. corner of Butler. If these points be connected on any map of the State this axis will be found to assume a fairly sinuous course; but unfortunately our geography of the State is not as yet sufficiently accurate to affirm this wave structure. Still it is sufficiently good to permit of the statement that this axis is *not* a straight line.

Continued into Allegheny county it keeps a pretty direct course as far as Girties run, where it is deflected southwards to the Ohio river in the neighborhood of Woods run.

It enters Allegheny on the north in West Deer twp., passing west of Culmersville, having previously brought up the *Upper Freeport coal* on Big Bull creek near Lardintown and Pughtown, and crosses Big Deer creek, just above Martin's coal works, at Saxonburg, where it again brings the Upper Freeport coal to daylight.

Passing through Hampton twp. at the 12 mile house, it reaches Pine run at the big bend above Herron station on the Pittsburgh & Western R. R.; elevating the *Freeport coal* 50 feet above the stream and keeping it exposed for 3 miles along the creek.

From here it makes directly for Girties run, which is crossed above Evergreen, at the forks of the stream. Thus far its course has been pretty direct and is substantially as laid down by Prof. White in Report Q., p. 20

It was incidentally identified with the *Washington anticlinal* to be immediately described, both by Prof. White and in the Report of 1885; but recent surveys have shown that it fairly laps past the latter axis, deflecting southwards at Girties run to Woods run on the Ohio, 3 miles below Pittsburgh; crossing the river to the Panhandle railroad just east of Sheridan station, and dying rapidly southwards in the ridge half a mile east of Idlewood station.

There is certainly a reversal of dip at Sheridan station, depicted in the Crinoidal limestone and accompanying rocks of the Barren Measures, the Pittsburgh coal being in the hill tops 1100′ above tide.

One mile to the south-west, the Pittsburgh bed is opened on the plank road at Wettengill's and Gormley's country pit at 1080′, dipping south-east, and at Hodgson's pit at 1090′, dipping north-west on opposite sides of the axis.

At the Craft and Phœnix pits, 1052′ and 972′, the dip is north-west into the Mansfield synclinal; while at the Sterrett pit, 978′, 1¼ miles from the railroad, the dip is south-east.

On Whisky run, further south-west, no change of dip was observed, all the coal draining directly from the Washington axis north-west into the Mansfield synclinal.

Prof. White calculates the rate of fall south-west of this Brady's Bend axis north of the river at 22′ per mile on a S. 40° W. course, though south of the Ohio River, its decline is much more rapid, falling from 1100′ to about 960′ A. T. on the arch east of Idlewood station, or 140 feet in a little over 2 miles.

The southeast slope of this anticlinal is very sharp, and reaches as high as 3° or 5′ per 100′; near its crest on Bull creek, about 4 miles south-east of the main anticlinal, a subordinate, but sharp roll was noticed. (See Report Q. 21.) It crosses just below the mouth of McDowell's run, reversing the dip for about ¾ miles north-west, when the strata rise without interruption to the Brady's Bend axis towards Millerstown.

Economically considered, this latter axis is of great importance to the citizens of Northern Allegheny, for without its influence in elevating the Freeport coal above water level on several of the larger streams, they would be obliged to look to the Pittsburgh coal, further south, for the fuel, which could only be distributed for domestic purposes at considerable additional expense over that now required to obtain the Freeport coal.

The latter bed too, fortunately exists in good shape, quite suitable for all domestic purposes, though of course inferior to the matchless *Pittsburgh bed*, here only preserved in patches in the highest hills and generally worked out.

4. *The Washington Anticlinal.*

This, the next succeeding rock wave, suggests from its location some relationship with the Brady's Bend axis although conveniently considered as distinct. It has expired northeast in the high plateau south of the Ohio river near Pittsburgh; just as the other has been shown to decline southwest in the ridge east of Idlewood. All the country hereabouts is high land, no doubt the result of the overlapping of these two great anticlinals; and in all the breadth of country so affected, along the Ohio terrace, the Pittsburgh bed varies slightly from an elevation of 350′ above the river or 1050′ A. T., sometimes higher and sometimes a little lower.

The *Washington Anticlinal*, in its course through Allegheny and as far as Houston station in Washington Co., keeps a remarkably straight line, but gradually subsides south-westward. But if it is to be made coincident with the similarly named axis beyond Washington, as laid down in Report K., its course must be deflected a little to the south from somewhere about Houston or Ewing station.

For its location from there to the West Virginia line, Prof. Stevenson's notes are used. In the broad plateau of the Pittsburgh coal carried at 1040′ ± A. T., on its arch above the Monongahela river at Pittsburgh, it occupies a position approximately opposite the Birmingham railroad bridge. From here it extends southwest to the vicinity of the borough of Beltzhoover (where the Pittsburgh coal is about 980′ A. T.,) and soon assumes a course practically coincident with the Washington pike. From this ridge the drainage extends west clear to Chartiers creek, the Brady's Bend axis having expired before reaching Whiskey run.

Continuing southwest into Scott township, the axis still extends along the pike to Mt. Lebanon P. O., where the road diverges while the anticlinal keeps straight on for Upper St. Clair township.

Shortly after entering here, it is well marked and its arch exposed on Painter's run which it crosses about midway between the Essen and Harrison mines, with the Pittsburgh coal on its crest at about 900′ A. T. Its decline thus far from the river, a distance of about 6 miles in an air-line, is (1040-900) 140′ ± or a rate of 23′+ per mile.

It crosses McLaughlin's run, the next stream south, in the neighborhood of McMillan's mine, 862′ A. T., something over a mile above Bridgeville station on the Chartiers Valley railroad.

In all the country south of this in Allegheny Co., the Pittsburgh coal is deeply buried, by reason of the gradual sinking of the measures, and the definite position of the axis thereby obscured. But it is fairly well defined crossing the Chartiers railroad and creek above Hasting's station, and reaching the Washington Co. line about 1 mile west of the creek, beyond the M. E. church. After passing through Cecil under a covering of the Upper Productive measures, it again brings up the *Pittsburgh coal* at Cannonsburg at about 935′ A. T., showing a temporary increased strength. From Cannonsburg it passes a little west of the railroad at Houston station and the numerous openings along Chartiers creek further south all report a north-west rise of the coal into Chartiers twp. Developments, however, have not been sufficiently extended to define the position of the axis closely; but in this neighborhood, it is most likely turned southwards slightly, passing near Ewingsville, with the coal about 975′ A. T., crossing the Wheeling Div. of the B. & O. R. R. about 1 mile west of Washington; passing through the south-east corner of Buffalo twp., and through the village of East Finley beyond.

It enters Greene a little above the mouth of Owens run in Richhill twp., and crosses South Wheeling creek barely half a mile below the mouth of Crab-apple. Beyond that it soon passes into West Virginia.

It brings up the *Waynesburg coal* in South Wheeling in Greene Co., as well as on Hunter's fork between the two counties and with a display of the *Pittsburgh coal* along Chartiers creek, caused by its presence, its economical effect upon the region's resources can be well imagined.

5. *Pin Hook Anticlinal.*

This important axis has been identified by other observers as the *Bagdad anticlinal* of Armstrong Co. and the *Brook-*

ville axis of Jefferson Co. While in places indistinct in those two counties, it keeps a fairly straight line all through Jefferson, which may be continued directly south-west as far as Cowanshannock creek in Armstrong.

Here, like all the axes to the south-east in Armstrong Co., it is deflected considerably to the west in its course and reaches the Kiskiminetas river at Bagdad station. From here to the Monongahela river, it keeps practically the same course, generally parallel to the Allegheny river, which stream is only about 1½ miles from the axis in the latitude of Sandy creek.

Thus far it has passed through Allegheny and Lower Burrell townships of Westmoreland Co., reaching Pucketa creek about a mile from Parnassus P. O. on the river.

The general absence of key-rocks, in a country so largely occupied by Barren Measure rocks, prevents a more definite location of the course of this axis, remarks indeed applicable to its continuation to the Monongahela river. In its south-west course from Pucketa creek, it passes close to the river in Plum twp. of Allegheny; reaches Plum creek in the vicinity of Milltown; passes just west of M. Graver & Co's coal mines in Penn twp., where the *Pittsburgh coal* is just eroded from its arch; reaches the Sandy Creek railroad about ½ a mile above White Ash P. O., or Sandy Creek village, and just in front of the numerous mine openings of the New York and Cleveland Gas Coal Co.; carries the *Pittsburgh coal* on its crest a little south-west from the creek; passes through the town of Wilkinsburg and reaches the Monongahela river at the mouth of Nine Mile run, or near Salt Works Sta. on the B. & O. R. R.

Its course is largely marked by exposures of the Barren Measure rocks along Nine Mile run and through north Penn and Plum townships; the Pittsburgh coal everywhere dipping from it to the south-east into the trough of Turtle creek and Thompson run.

It will be noticed that thus far its position has been moved very much farther westward than given in the former reports of the survey. Then its course north of the Monongahela river was continued directly north-east through the center of Wilkins and Penn townships; but an inspection of the Pittsburgh coal levels on the general map will demonstrate most conclusively that there is no interruption in the steady south-east dip of the measures, from the line just described to Turtle creek, which marks the line of one branch of the *Waynesburg synclinal.* This dip here amounts to about 33 feet per mile.

South of the Monongahela river, the *Pin Hook axis* assumes an entirely different position, and for all practical purposes, it could be considered as a distinct axis. But no separate name has been given to it heretofore, and it is not necessary or wise to introduce one now.

Leaving the Monongahela river opposite Braddock and about ½ mile below Green Springs Station on the P. V. & C. R. R., it takes a S. 30° W. course for the Washington line which it crosses near the 12 Mile House, 4½ miles from the river. Between these two points it passes a little west of the Bellwood mine opening, and through the Lebanon school house in Mifflin township, meeting the Jefferson township line near the crossing of the middle branch of Lewis run. Passing through the north-west corner of Jefferson, it intersects the Wheeling Division of the B. & O. R. R. and Lick creek about ¾ miles above Cochran's mills; then through south-eastern Snowden, to Piney fork near the mouth of Cat Fish run, to 12 Mile House. Beyond this in Washington Co. this axis extends through Union township as a faint wave to the centre of the rectangular offset in the Peters twp. line, where deflecting slightly southwards it touchs Peters creek above the Venetia mine in the vicinity of Thomas saw mill; and thence describes almost a straight line through Nottingham twp. to Mingo creek, which is crossed near the residence of Mr. Leyda.

No further personal examinations of its course southwest from this point were made; and even in the Nottingham twp. its course was not well made out.

The description of its location further south in Washington Co. is mainly that of Prof. White in Rep. K. p. 28.

"As it enters Somerset township it seems to be suddenly thrown eastward, for it is seen crossing the North fork of

Pigeon creek near school house No. 7, fully one mile out of its course. No other deflection occurs in this county. The crest crosses the south fork of Pigeon creek near Vanceville and the National road in West Bethlehem, about four and one-half miles west from Hillsborough. In Amwell township it passes north from Pin-hook, or Pleasant Valley, and directly through the village of Amity, reaching Ten-Mile creek on the line of Morris township. As it enters Greene county the course is again thrown eastward, and the axis appears in Washington township of that county as an obscure anticlinal, crossing Ruff's creek above the store; in Franklin, crossing Brown's fork near Rees' mill; in Centre, Gray's fork at Clinton; and it is probably the insignificant fold observed just west from Jolleytown on Dunkard creek."

It is fairly possible that the numerous offsets mentioned in the above description may be eventually connected by a sinuous line; but it is more than probable that this great axis is much broken here, and its component parts shoved past each other and overlapping.

In any event the structure of the country occupied by it will no doubt be but little understood until some more data is furnished by borings to the *Pittsburgh coal.*

The flattening southward, taking the coals as the basis, is very great. At Pin-hook the *Waynesburg* is 20 feet above the stream, while at the crossing of Ten-Mile, the *Washington* is at the same distance above the creek. The latter locality is about 60 feet lower than the former, and the interval between the coals is about 140 feet, so that the flattening, in a distance of less than seven miles, is not far from 200 feet. Taking the coals as a base, the height of the wave in Greene county is about 25 feet on Dunkard, and 40 feet on Gray's fork; in Washington county it is 80 feet on Ten-Mile, 260 feet at Pin-hook, 300 feet at Peters' creek; and in Allegheny county 340 feet at Braddock's station.

But between the Peters creek and the Monongahela river outcrops the rate of rise north-eastward decreases considerably. The two points are on an air line along the crest of the anticlinal about 6 miles apart, and the difference in elevation of the Pittsburgh coal (1075-970) 105 feet or about 18 feet per mile.

6. *Roaring Run or Murraysville Anticlinal.*

Between the Kiskiminetas and Monongahela rivers in Westmoreland and Allegheny counties, there seems to be but one broad basin—the *Waynesburg synclinal*—nearly 8 miles wide, as measured from the crown of the Bagdad or Pin-Hook axis to the Roaring Run axis. Along the former stream, and north-east into Armstrong county the basin is subdivided by the *Apollo anticlinal*, extending from the river, 1 mile below Apollo, northeast to Crooked creek, which it crosses ½ mile below Cochran's mills.

But no such sub-division seems to exist south of the river. The *Roaring Run* or *Murraysville axis*, which is identical with the *Fourth axis* of the First Survey, and with some modifications, with the *Peters Creek axis* of the report of 1875 (K. p. 29) seems to be now a most thoroughly established axis, and considerable space was given to its location and description in the Annual Report of 1885 on account of the preëminence it has attained through the numerous gas-wells of the now famous Murraysville axis. It is for that reason that its old name has been coupled with that of Murraysville, for it is by the latter that it is best known in the district with which this report is concerned.

Although the grounds for its identification and location were fully set forth in Chapter II of the Report of 1885, they are reprinted bodily below, even at the sacrifice of some slight difference in the arrangement of description from north southwards.

Its extension far south-west of the country lying between the two rivers, seems to be as indefinite and obscure as it was in 1876; but it is highly probable that the Washington county line, along the southern border of Jefferson township, in Allegheny county, fairly limits its extent in that direction.

Certainly no surface evidences of its presence in Washington county can be detected between the Monongahela river and Peters creek, the coal from the Coal Bluff and other mines on the river front lying nearly level or rising north-west with but little interruption to Peters creek.

Evidences of the existence of this axis, however, in Jefferson township, from a point a little south of Lock No. 3 to where it leaves the township north of Blair station on the P. V. & C. R. R., are apparent.

Its decline in approaching Washington county has no doubt caused the westward erosion of the river, as its presence at Blair station has certainly affected the course of the Monongahela there; likewise of the Youghiogheny south-east of McKeesport.

It will be observed that in restoring this Peters creek axis its position has also been shifted south-eastward, instead of passing through the *mouth of Peters creek*, according to report K, page 29.

The reasons for this are obvious.

All the coal along the *south* side of the Monongahela river lies lower than that *north* of the river along the crop; therefore the dip is *south-east* between the two outcrops.

In whatever position the coal lies in the hills along the river front above the Monongahela division of the P. R. R., or P. V. & C. R. R., (and the probability is that it is very flat,) we know, from actual development, that it soon dips to Peters creek, the crop there being anywhere from 50 to 70 feet lower than on the river, though a large "swamp" has been developed in the Walton workings close to the creek crop.

The same features are repeated further west where the *Hilldale mine coal* at 869′ A. T. is practically at the same level as the several country pits opened on Peters creek, opposite the mouth of Lick run. From Hilldale (Washington county) the coal dips *north-west;* from Peters creek, decidedly *south-east*, the trough between carrying a swamp. From Peters creek everything rises rapidly north-west to the Pin-Hook axis.

Crossing the river near Blair's station, the course of this anticlinal for the next 1½ miles to the Youghiogheny at Long Run station, on the B. & O. R. R., can be followed on the map.

Some idea of its strength and prominence can be gained from a comparison of the coal levels on or near its crest, and in the resulting synclinal basins north-west and south-east.

From the axis to the outcrop of the Pittsburgh coal south of Reynolds, (McKeesport,) is, in an air line, $2\frac{1}{4}$ miles, the difference in coal level being fully 170 feet, or about 75 feet per mile.

From the axis south-east to Buena Vista is about 4 miles, and the difference in coal elevations 300′ or an equal rate per mile of 75 feet.

In Versailles township, on the north-east side of the Youghiogheny, there is hardly any Pittsburgh coal left, the whole township being eroded and furrowed down by Long and Jack's runs, and exposing little else but the Barren Measures.

What few isolated patches have been left east of Jack's run, and along the Westmoreland county line, all evince a strong *south-east* dip, while, at the same time, rising to the *north-east* in obedience to the general laws governing the rise in that direction of the plane of the various axes of this district. The exact position of the axis in this township beyond the Youghiogheny river cannot be located, in the absence of some key rock; but in North Versailles township, it crosses the Pittsburgh and Greensburg pike not far from the M. E. Church, and within 700 yards of the Westmoreland county line.

Miller's coal here is nearly 1200′ A. T., and in 2 miles north-west the coal falls 160 feet.

A barren streak divides this coal from the Irwin basin in North Huntingdon township, Westmoreland county, the axis extending north-east to the Penna. R. R., between Carpenter's and Stewart's stations, following Turtle creek to Murraysville, and thence to Roaring run on the Kiskiminetas river.

In restoring the Peters Creek axis, therefore, to its place in the district, we can omit the new name, which, after all, is not very appropriate, and simply call it the *Roaring Run* or *Murraysville axis.* Its importance cannot be over-looked, and in the development of Natural Gas upon the "anticlinal theory," this axis has been more prominently brought forward than any other within the vicinity of Pittsburgh, owing to the large and productive wells located on or near it at Murraysville, Westmoreland county.

Its rate of rise north-eastward through Allegheny county is very marked. Taking the Pittsburgh bed as a basis, the rate between where it leaves Washington county and where it enters Westmoreland, is fully 27′ per mile, the coal levels being respectively 860′ and 1200′ A. T., and the distance in round numbers through Allegheny, 12 miles.

The Pin Hook axis overrides it in importance in Washington county beyond the Allegheny line; but it becomes obscure as well along Mingo creek, and it is quite probable that the anticlinal extending from the region of Dunningsville through Pleasant Valley and Amity, about midway between these two, may be regarded as an extension of either or as a resultant of both.

7. *The Waynesburg Anticlinal.*

The *Waynesburg anticlinal* has been generally regarded as a southern exponent of the *Saltsburg axis*, to be immediately described. But though that thought was shared with others, in the report of 1885, the structure of the whole region lying between the Pennsylvania R. R. and the Youghiogheny river, which would be occupied by an extension of either one of these to meet the other, is still too obscure to warrant classifying them as one and the same wave.

The *Waynesburg axis* is first seen as an exceedingly gentle wave on the Youghiogheny river just below the mouth of Sewickley creek and Pollock's run.

It here reverses the dip of the coal between Suter Station and Amieville, and causes an excessively irregular drainage throughout the Bigley mines.

From here it passes south-west through the extreme south-east corner of Forward township, crossing the Westmoreland county line about 1600 yards from the river, and keeps a pretty straight course to the Monongahela river above Webster.

While it shows the same general rise going north-east as the other waves of the district, this increase is interrupted between the two large rivers, falling, going north-eastward, in that section about 150 feet in 8 miles. It is owing to this decline that its position is so obscure, and its effect so insignificant, on the Youghiogheny river.

The axis only touches the Monongahela at Webster, not crossing that river until about a mile below Bellevernon, where it carries the Pittsburgh coal on its crest at 1000′ A. T. At this point the axis attains its greatest strength, declining both ways, towards the Youghiogheny and towards Waynesburg.

From the Monongahela river to Waynesburg, in Greene county, it describes a practically straight line for 22 miles, and the following is a notation of points touched by it, according to Report K, p. 26:

"It passes through Allen township half a mile west from Speer's mill, and through West Bethlehem township near Centreville, where it brings up the *Pittsburgh coal.* It crosses the North Fork of Ten-Mile creek near Hawkins' mill, and enters Morgan township in Greene county. In this township it crosses Ruff's creek about a mile below Martinsburg, and enters Franklin township, where it crosses the S. Fork of Ten-Mile below Dodysburg, and Smith creek near the Brick school house.

"If this course were maintained, the axis should cross Dunkard creek near the western limit of Wayne township; but no axis is found there. In the interval, exposures are so rare and unsatisfactory that tracing is altogether out of the question. It is probable that near the southern boundary of Franklin township it is thrown off to the east, for a well marked anticlinal was found at Blacksville on Dunkard, near the eastern border of Wayne township. This is the place where the synclinal east from this axis should have crossed the creek. It is quite evident that the fold disappears soon after entering West Virgina."

Between the Monongahela and Ten-Mile creek it sinks 300 feet, the distance being 22 miles.

An obscure and questionable axis shows itself in an irregular roll extending along a line parallel with Sewickley creek, north of the Youghiogheny river for a short distance; but no significance can be attached to it as indicating the extension of the Waynesburg axis.

8. *The Saltsburg anticlinal.*

This anticlinal, if it be not associated with the Waynesburg axis just described, mainly affects the district lying between the Conemaugh river and the Pennsylvania railroad.

It is an important and well-defined wave in Indiana county, and was formerly identified with the *Fayette axis* on the south, to be presently described. This latter association is hardly more admissible than to identify it with the Waynesburg axis; for south of the Penna. R. R. its position is entirely obscured by the mantle of Barren Measure rocks which cover that territory.

The axis leaves the Conemaugh about 2 miles above Saltsburg near White's station; brings up the *Upper Freeport coal* along the Loyalhanna at James Snodgrass' mill; the Conemaugh pike in the immediate vicinity of Harveys Five Points; the Pennsylvania railroad just west of Grapeville station and the Pittsburgh and Greensburg pike near the village of Grapeville, elevating patches of the *Upper Freeport coal* to daylight both north and south of that place. It is not possible to trace it further south-west as a distinct axis, for a prolongation of its course between the Conemaugh and the Penna. R. R., would pass it through Arona and West Newton on the Youghiogheny where no such anticlinal flexure exists.

Immediately after passing the Pittsburgh and Greensburg pike at Grapeville, it either subsides altogether or is deflected in its course towards the south, and its presence illustrated by the exposure of the Lower Productive coal measures along Little Sewickley creek north of Middletown in Hempfield township.

The map coloring will show this and likewise displays a considerable outcropping of the *Freeport measures* on Big Sewickley creek, where an anticlinal axis crosses close to the mouth of Jacks creek.

This locality seems to be a common intersection of forces exerted by the *Saltsburg*, *Indiana* (or Blairsville) and *Fayette* axes, and while nothing positive can be said concerning the structural features governing this troubled region, generally occupied by Barren Measure rocks, it would seem as if the north-eastern subsidence of the Fayette anticlinal, as a separate roll, along Big Sewickley creek, has given rise to the forking of *two* anticlinals, enclosing the *Greensburg basin*, respectively the *Saltsburg anticlinal* on the west and known locally as Brush or Grapeville ridge; and the *Indiana* or *Blairsville anticlinal* (to be described immediately) on the east, known in Westmoreland county as Huckleberry ridge. At all events, whether this association be maintained or not, the structural lines as laid down on the map, fairly represent the flexures affecting the economical resources of the region.

It is estimated that on the Penna. R. R. along the crest of the Saltsburg axis the Pittsburgh coal, if it had not been eroded, would rest at about 1500′ above tide, and on the Conemaugh, 15 miles distant, at 1600′ A. T. The axis, therefore, while marking high land between these points, is very flat itself.

9. *The Indiana or Blairsville anticlinal.*

This wave, called by either of the above names, though preferably the former, has for reasons just stated, about the same south-western extension as the Saltsburg. It is the *Third axis* of the First Survey, and in Indiana county is a very important wave, passing through the county seat and reaches the Conemaugh river in the great bend below Blairsville.

Passing through Derry township of Westmoreland, "it crosses the Conemaugh pike near Spruce run, the Loyalhanna, near Braely's old mill, and the Penna. railroad a short distance east from Carr's tunnel." (K. K. p. 14.)

To the Pittsburgh coal region this axis is of no significance, for south of the railroad, it can not be located more than 3 or 4 miles in the obscure exposures of the Barren Measure rocks, although it is probably responsible for a large measure of the effect produced along Big Sewickley creek already mentioned. In this county it is known under the name of Huckleberry ridge. It brings up the *Upper Freeport coal* on the Loyalhanna, and the dips on either side of its arch are quite sharp. Its position is generally marked by a strip of Barren Measures.

10. The Fayette anticlinal.

For the present this axis may be conveniently treated as a separate fold, though possibly the resultant of the two axes just described, and continuing their effects in the geology of the district, between Big Sewickley creek and the West Virginia State line.

Between the creek and the Youghiogheny river it is somewhat obscure, crossing Jacobs creek about 3 miles from the river, where it elevates the Lower Productive Measures to daylight, and creates a similar effect on the river near the mouth of Virgins run.

Following this stream and the Perry-Franklin township line closely, going south-west, it passes a little west of Flatwood P. O. and reaches Redstone creek above the mouth of Bolands run, where it again brings up the Lower Productive Measures; passes nearly a mile west of Upper Middletown and reaches the National Road about 3½ miles from Uniontown and a little west of the school house. From here it keeps a little more to the west but on a straight course, crossing Dunlap and Brown creeks about a mile from the Georges township line, with Barren Measure rocks on its crest, and enters Nicholson township near the headwaters of Jacobs creek.

It keeps well on the eastern side of this township, passing through the divide separating York run from a branch of Jacobs creek, and carrying here quite a patch of the *Pittsburgh coal* on its crest.

George's creek is crossed above Crow's mill; thence a little east of the Methodist Church on the road from Morris X Roads to New Geneva, and a mile due west of the former place, and finally crosses the Cheat river, a short distance above its mouth and into West Virginia. While not an absolutely straight line throughout its course, this axis is very direct and of the greatest economical importance to the district through which it passes.

Here too, in Fayette Co., it is generally known as Brush ridge.

Though carrying a light cover of the Upper Productive Measures towards the south, the line of the axis is generally marked by a strip of Barren Measures, and creates a distinct topographical feature of the district. It shows a decided increase of strength in going northward, with the effect of creating very sharp marginal dips along the outcrop of the *Pittsburgh bed* in the Lisbon and Blairsville coal basins. In the point between the Monongahela and Cheat rivers, the *Pittsburgh coal* rides over its crest at 1150′ A. T.; on Redstone creek the Upper Freeport coal occupies a similar position, at a little above 900′ A. T. Assuming an interval of 600′ between the beds, this would indicate a difference of elevation in the axis of about 360 feet in 18 miles, or an average north-east rise of 20′ per mile. From here the rate decreases, or the axis is nearly level, the same lower coals showing on the Youghiogheny, Jacobs creek and Big Sewickley at very nearly the same elevation, being only 100′+ higher on Big Sewickley than on Redstone, the distance being almost 18 miles.

11. Chestnut Ridge Anticlinal.

12. Laurel Hill Anticlinal.

It is not necessary to enter into any description of these great rock waves here, for they lie entirely without the district, and have been sufficiently described in other reports of the survey.

Details respecting the position of the other anticlinals already referred to in this chapter must be sought for in the chapters on township geology. So, too, with the synclinals. The limited development of the field, considered in its entirety, prevents anything but a most general statement concerning the synclinal basins, for manifestly the line denoting change of dip, has been fixed at comparatively few places, and these widely apart. A hundred local swamps or rolls modify any attempt to locate such lines from outcrop exposures, and it was shown in the Annual Report of 1885, by means of contour lines representing the floor of the *Pittsburgh coal bed*, how sinuous and irregular the floors of these great basins really are.

It is well however to enumerate the basins and the anticlinal axes which separate them.

The Synclinal coal basins.

These synclinals are 10 in number and are arranged from west to east, somewhat as follows:

1. *Burgettstown synclinal*, lying west of Bulger anticlinal.	
2. *West Middletown synclinal*,	Bulger anticlinal. Claysville anticlinal.
3. *Mansfield synclinal.*	
4. *Nineveh synclinal*,	Washington anticlinal. Pin-Hook anticlinal.
5. *Allegheny river synclinal*,	Brady's Bend anticlinal. Bagdad anticlinal.
6. *Waynesburg synclinal*,	Pin-Hook and Waynesburg anticlinals. Pin-Hook and Roaring Run anticlinals. Roaring Run and Bagdad anticlinals.
7. *Lisbon* (Irwin) *synclinal*,	Roaring Run and Saltsburg anticlinals. Waynesburg and Fayette anticlinals.
8. *Greensburg synclinal*,	Saltsburg anticlinal. Indiana or Blairsville anticlinal.
9. *Blairsville* (Connellsville) *synclinal*,	Indiana and Chestnut Ridge anticlinals. Fayette and Chestnut Ridge anticlinals.
10. *Ligonier synclinal*,	Chestnut Ridge anticlinal. Laurel Hill anticlinal.

These ten principal troughs are sub-divided in various places by local anticlinals and the sinking and overlapping of the chief anticlinals give all the troughs an irregular curving shape, almost defying definite description.

This fact will be best understood by reference to the map, from which at least the relative position of the various basins may be inferred.

1. The *Burgettstown synclinal*, so called from being best developed near the station of that name on the Panhandle railroad, is an insignificant and obscure basin, lying outside the proper limits of the district, of which the following general statement is made in Report K, p. 32:

"It enters Beaver county near Hog Island on the Ohio, crosses Raccoon creek below the mouth of Tramp run, Big Traverse near Keifer's mill, and reaches Washington county at Frankfort. * * * Like the axis, it is evidently shifted (?) east, and is well marked at the railroad, which it crosses at Burgettstown, 4 miles west of Bulger. This trough disappears southward, and cannot be found in the southern part of Smith township, nor in Cross Creek township."

2. The *West Middletown synclinal* is an extremely shallow basin, lying between the Claysville and Bulger axes.

It is said to cross Buffalo creek about a mile from the West Virginia line, passes north-east through West Middletown; a little west of the village of Hickory, and thence very faintly marked on the Panhandle railroad near McDonald and to the Ohio river near the mouth of Montour's run. It cannot be well traced north of the river, showing faintly only at the mouth of Kilbuck run, and nowhere in Allegheny does it exert a fairly perceptible influence upon the dip of the rocks.

The entire basin is not over 3 miles wide.

3. The *Mansfield synclinal* is the first important basin in the western part of the district, lying south of the Ohio river and between the Claysville and Washington axes.

It is indistinct on the river, but passes through Stowe township of Allegheny county, about ½ mile west of School House No. 7, with the *Pittsburgh bed* in its trough at about 1100′ A. T.

Southward it soon takes up a course practically coincident with Chartiers creek, and crosses the Panhandle railroad at the town of Mansfield, where the Pittsburgh bed would be about 850′ A. T., or a fall of 250′ in about 5 miles.

This agrees closely with the rate of subsidence on the Washington axis. From Mansfield to Bridgeville, about 4 miles *air-line*, its position is approximately that of Chartiers creek, and its axis declines only about 30 feet. South of Bridgeville, the Pittsburgh bed sinks rapidly beneath water level, and the synclinal is obscure, crossing Millers run about ½ mile above its mouth, and the left hand fork of Chartiers creek, in Washington county, about ½ mile below McConnell's mills, with the Pittsburgh bed at about 1000′ A. T., showing therefore a south-westward rise from the vicinity of Bridgeville of nearly 200 feet in 10 miles.

Further south-west it was not traced, but is said to cross the Wheeling division of the B. & O. R. R. about 1 mile west from the eastern line of Buffalo township; Robinson's fork in West Finley about 3 miles below the village of Good Intent; and thence into West Virginia.

By tracing its course on the map, it will be seen that it by no means describes a straight line, and lies closer to the Washington than to the Claysville axis.

4. The *Nineveh synclinal* lies between the Pin-Hook and the Washington anticlinals. Like all other basins, its outline is irregular; it is divided in two by a subordinate anticlinal along the Monongahela; and is very obscure in Allegheny county owing to the limited development that has so far been made within it.

Its centre line seems to touch the river in the neighborhood of Walton & Co.'s Six Mile Ferry works or near Lucas station, and passes south-west beneath the Point View Hotel on the Brownsville road. From here southwards its position is indefinite, owing to the absence of reliable guides to its establishment; but probably just touches the B. & O. R. R. near Miller's Grove; Lick creek near the summit forks; School house No. 7 in Snowden township, and passes into Washington county about half-a-mile east of the Upper St. Clair-Snowden line. Streets run marks the line of the eastern-subdivision of this basin, the coal dipping to it from both sides; Becks run and Little Saw Mill run above Fairhaven marking the western sub-basin. How far to the south-west this division of the basin maintains its integrity, it is impossible to state, as but little work has been done in this part of the field.

The basin is 5 or 6 miles wide in the latitude of Washington and its position is thus outlined in the report of 1875, K, p. 29:

"It enters North Strabane township, Washington county, at its north-eastern corner, and passes out of it near Clokeysville into South Strabane township. It crosses the National road a little east from the village of Martinsburg, and enters Morris township near the point where Amwell, Morris, and Franklin join. In Morris it passes almost directly through Prosperity. Here it is thrown eastward to coincide with the deflection of the Pin-hook anticlinal, and enters Greene county about two miles east from its true line. In that county it crosses Brown's fork of Ten-Mile about half a mile north from Nineveh; Gray's fork about a mile east from Graysville; the Dunkard fork of South Wheeling at the south-east corner of Richhill township; the Aleppo fork of the same stream near the line of Aleppo and Springhill township; and passes into West Virginia at the extreme south-west corner of the State. From North Strabane township, Washington county, this trough is very distinct and is traceable without difficulty."

5. The *Allegheny river synclinal* is a name given to the general basin 9 miles wide lying north of the Ohio river, and between the Brady's Bend and Bagdad axes.

It is sub-divided in Fawn township of Allegheny county by a local but sharp anticlinal crossing Bull creek above School House No. 4 and about 4 miles south-east from the line of the Brady's Bend axis, and keeping the Freeport measures above water on that stream for some distance. The general basin, which is identical with the *Fairmount synclinal* of Armstrong county, passes through Kittanning and Freeport—both on the Allegheny river—and crosses and recrosses that stream on its way to Pittsburgh. It is not of much commercial importance to the Pittsburgh coal district, although the Freeport group of coals is exposed along the river, in its trough, near to Kennedy Station on the West Penn R. R.

6. The *Waynesburg synclinal* is one of the most important basins in the district.

It is about 8 miles wide on the Kiskiminetas, although sub-divided there by the Apollo axis into the *Leechburg sub-basin* on the west, passing through Leechburg, and the *Apollo sub-basin* on the east, passing through the village of that name, and about 1 mile up stream from the sub-axis.

In northern Westmoreland and Allegheny county, largely occupied by Barren Measures, are patches of the Pittsburgh bed. It is not possible to carry out this sub-division. Both these minor basins seem to unite, at all events south of Pucketa creek, into one basin, coursing through the N. Y. & C. Gas Coal Co.'s Plum Creek mines, with the Pittsburgh coal at about 1080′ A. T., and soon afterwards taking up a line coincident with Thompson's run, which evidently runs in the trough between the Roaring Run and Bagdad axes as far as its junction with Turtle creek and the Penna. R. R.; thence along Turtle creek to the Monongahela river at Port Perry, and, as shown in the annual report of 1885, following the river southwards to the vicinity of Rock Run station, and thence to the Washington county line, about 2 miles from the river.

But just here the Roaring Run or Murraysville anticlinal expires, and allows the basin to swing around its end. Here, then, the eastern half of the basin is confined between the Pin Hook and Waynesburg anticlinals; is, nearly 10 miles wide and about 250′ deep.

This part of the basin is further sub-divided by a subordinate axis passing through Monongahela city, which apparently expires as the entire basin shelves up north-eastward before reaching the Youghiogheny. On that stream there is no interruption of the south-east dip from the Murraysville axis to Guffey's station on the B. & O. R. R., where again the expiration of the Waynesburg anticlinal permits of merely a gentle roll into the *Lisbon basin*. The whole basin structure of the region is exceedingly diversified, and does not admit of any sharply defined outlines, as the levels of the Pittsburgh bed on the map will show. South-west of the Monongahela river, its course through Washington and Greene county is thus laid down in K, p. 27:

"* * * From Monongahela city, it crosses through Carroll, Fallowfield and Somerset townships, where it is closely followed by the channel of Pigeon creek; it passes a little east from Bentleysville and enters West Bethlehem, where it crosses the North Fork of Ten-Mile creek near Zollarsville. Beyond that locality it becomes very shallow and is traced with difficulty.

"In Greene county it crosses Ruff's creek near the eastern line of Washington township, Ten-Mile near the mouth of Brown's fork, and Dunkard not far from Dent P. O. in Wayne township."

It is commercially the most important and most largely developed basin in the Pittsburgh coal region, though sharing that distinction with the Lisbon basin to be immediately described.

7. The *Lisbon synclinal* is the famous gas-coal basin of the district and known as the *Irwin basin*, along the line of the Pennsylvania railroad in Westmoreland county.

North of the Conemaugh it is sub-divided by the Perrysville axis into the *Smicksburg* and *West Lebanon* subbasins. A somewhat detailed description of the basin between the Conemaugh and the Penna. R. R. will be found in Chap. VIII, so that it need only be said that its eastern slope is very much more abrupt than its western, and that consequently the plane of its axis lies nearer to the Saltsburg than the Roaring Run axis.

It crosses the Conemaugh about 3 miles below Saltsburg; passes a little west of New Salem (1 mile ±); west of Harrison City, and touches the Pennsylvania railroad at the bridge between Westmoreland City and Manor Station, where the Pittsburgh coal is 750′ A. T.

As the Saltsburg and Indiana anticlinals blend together or approach each other south of the railroad, the axial line of the Lisbon basin is likewise deflected towards the south, reaching Sewickley creek above Markle's mill, and the Youghiogheny at Port Royal, where the Pittsburgh bed is about 610′ A. T.

South-west from the basin soon becomes marked with a subordinate anticlinal, which indeed may exist elsewhere to the north-east, not yet developed in the deeply-buried coal.

The detailed position and character of the sub-basins and the axis will be found in Chap. IX.

The western sub-division crosses the Monongahela river just below the Umpire mine in Jefferson township. The eastern sub-basin passes through the eastern part of Jefferson, crossing Redstone creek just below Parkhill's mill, and reaches Dunlap's creek about 1 mile below the Menallen township line; Middle run a mile from the river, which it crosses a mile above the creek.

The sub-axis, really marking the plane of the synclinal, crosses Redstone creek a little below Linn station; passes obscurely through Brownsville township, and thence through Luzerne to the river near the mouth of Muddy run in Greene county.

"It passes nearly a mile south-east from Carmichaels; then through Greene township, and crosses Whiteley creek near the eastern border of Whiteley township; there it is evidently thrown eastward, for it reaches Dunkard creek at a little way east from the border of Wayne township, not far from Blacksville. The precise line of this axis is ascertained with some difficulty, as along it there occur some subordinate anticlinals, very narrow but quite sharp, one of which is distinctly marked on Glade run near Carmichaels." K, p. 26.

8. The *Greensburg synclinal* is a canoe-shaped trough caught between the slopes of the Saltsburg and Indiana axes. North of the Conemaugh it is represented in Indiana county by the *Marion-Fillmore synclinal*, whose axis-line meets the Conemaugh near the tunnel at the horse-shoe bend.

The basin on that river is about 6 miles wide, and contains none of the Upper Productive Measures.

South-west the basin first spreads a little; but south of the Penna. R. R. the two axes converge rapidly in the region of Big Sewickley creek, and the basin shoals up suddenly. It is perhaps deepest at the Penna. railroad where it holds probably 250 feet of the Upper Productive

Measures. But the rocks rise rapidly from there, and the *Pittsburgh bed* is elevated far above the Loyalhanna at New Alexandria, and passes out of the hill-tops before reaching the Conemaugh. The axis crosses the Loyalhanna about a mile below New Alexandria and the Penna. R. R. just east of the Greensburg tunnel. As a whole the basin is shallow and quite regular, and does not seem to be subdivided. It lies outside of the district under discussion as the *Pittsburgh Coal Region.* So also do the basins still awaiting description. The first of these is:

9. The *Blairsville* (Connellsville) *synclinal*, the famous coking coal basin of the district.

This trough has the Chestnut Ridge anticlinal for an eastern boundary, while its western border is formed by the Indiana axis as far south as Sewickley creek and the Fayette axis from there to the West Virginia line. This basin was not examined at all during the present survey; but it is sufficiently described in Report KK, and its general position is shown on the map accompanying this report.

10. The *Ligonier synclinal* is the next and last basin of the series, confined between the Chestnut Ridge and Laurel Hill anticlinals, and following those axes in their course through Westmoreland and Fayette counties.

Comparatively little of the *Pittsburgh bed* is left without this fold, its surface rocks being largely composed of the Barren Measures and Lower Productive coal group.

It lies east of the area shown in the general map and of course wholly without the district under examination. In the township geology which follows, Chap. V. et seq., certain details and characteristic features of the various basins just described will serve to give some little additional information upon the position of the *Pittsburgh bed* in various parts of the field; but the limited development hitherto made in the neighborhood of the synclinal axes, prevents a more definite location of the axial lines than has been given in the pages of this present chapter.

Chapter IV.

Stratigraphical Geology.

The rocks which outcrop in the *Pittsburgh Coal Region* all belong to the last or Carboniferous Period of the Palæozoic ages; divided into four series as follows:

1. Upper Barren Measures, { a. Greene county group.
   b. Washington county group.
2. Upper Productive Measures or Monongahela River Series.
3. The Barren Measures.
4. Lower Productive Measures or Allegheny River Series.

Upon the general map accompanying this report the respective and relative areas of these four series are shown by reference to the scale of colors. Reference to previous reports of the survey upon the various counties of south-west Pennsylvania might lead to the inference that the vertical sections made of the same measures in widely different parts of the field denoted inaccuracy of measurements. But a careful investigation of the whole material presented, no less than a personal inspection of the field, will soon convince the most skeptical observer that there is absolutely no uniformity existing in the exposed rock sections, and that consequently no one vertical section, no matter how carefully compiled, will exactly or even sometimes approximately prove serviceable in studying the stratigraphical relations elsewhere. The *order* of deposition in the various strata is fairly well maintained; but character, thickness, and intervals all vary rapidly, and within narrow scopes, and so far no law governing the amount or direction of this variation has been discovered.

The Upper Barren Measures.

An inspection of the map will show, that the outspread of these, the most recent rocks in Pennsylvania west of the Allegheny mountains, and represented by the darkest tint, is confined to that part of the field lying *south* of a general east and west line, rudely coinciding with the Ohio and Monongahela rivers as far east as Port Perry and an extension of such a line along the Pennsylvania Central R. R.

North of this average line the rocks of this series nowhere exist, having been long ago swept away from the highest hill tops by a never ceasing atmospheric erosion, aided by the well defined rise of *all* the measures northeastward, in the various coal basins as along the anticlinal axes. Nor can these rocks be found in Allegheny county anywhere south of this line, except on the very border line of Washington county.

But on the other hand, nearly the whole of the great rolling plateau of the two counties south of Allegheny, is composed of members of the Upper or Greene County and Lower or Washington County groups, whose rocks have had their edges largely smoothed down by erosion and cultivation, until nearly the whole district is a continuous agricultural upland, where everything is plain sailing to the farmer, but a labyrinth of concealed stumbling blocks to the geologist.

The same rocks occupy considerable areas in that portion of Fayette and Westmoreland comprised in the Pittsburgh district, resting mostly in the Lisbon (Irwin) synclinal basin, along the western sides of those counties.

The extent of this series in Westmoreland county, however, is quite insignificant, barely reaching north of the Youghiogheny river and confined solely to the central line of the basin.

In the special description of these several counties, the specific variations of the series, and the two groups comprising it, will be referred to in some detail in treating of the township geology.

It will be sufficient now to give merely general statements concerning the series as a whole.

The dividing line between the subordinate groups has been fixed at the *Upper Washington limestone* No. VI, so that in all discussions of the upper and lower groups, this rock is assumed to mark the horizon of separation, marking the *base* of the Greene County group and the *top* of the Washington County group. The former group comprises all rocks in this part of the State *above* that rock, with an extreme thickness of about 800 feet. It is only well exposed in Greene county. The Washington County group extends from that limestone down to the top of the Waynesburg sandstone, and varies in thickness from about 450 feet in the southern portion of the district, to a little more than 150 feet in the north. Though thinner, it is more important in Washington county.

Typical and generalized sections of the rocks comprising these groups in Greene and Washington counties, where they are most fully exposed, are reproduced from Report K, on accompanying plate.

The respective strata comprising them are described in minute detail in that report, and specific discussion of them is not necessary here, especially as they received but little personal study during the past season, and wherever met with in the survey of districts where they are exposed, in part, with the Upper Productive Measures, they will be found described in the chapters on township geology.

Still the following description of the series as a whole may be of interest, and is taken, with some few alterations, from Prof. Lesley's summary of facts relating to these measures : *

But two salient features present themselves unmistakably :

1. The whole formation is evidently thinner in Washington county than in Greene county, and continues to thicken southward into West Virginia ; so that it is probable that the highest preserved bed is in Greene county, in spite of the superior thickness of the whole formation in Virginia ; for the thickening takes place in the body of the formation.

Its numerous limestone beds seem to have been deposited in a long north-east and south-west belt ; for if the geologist moves southward or south-westward into Virginia, he finds the limestones disappearing from his column, being replaced to a large extent by sandstones and shales.

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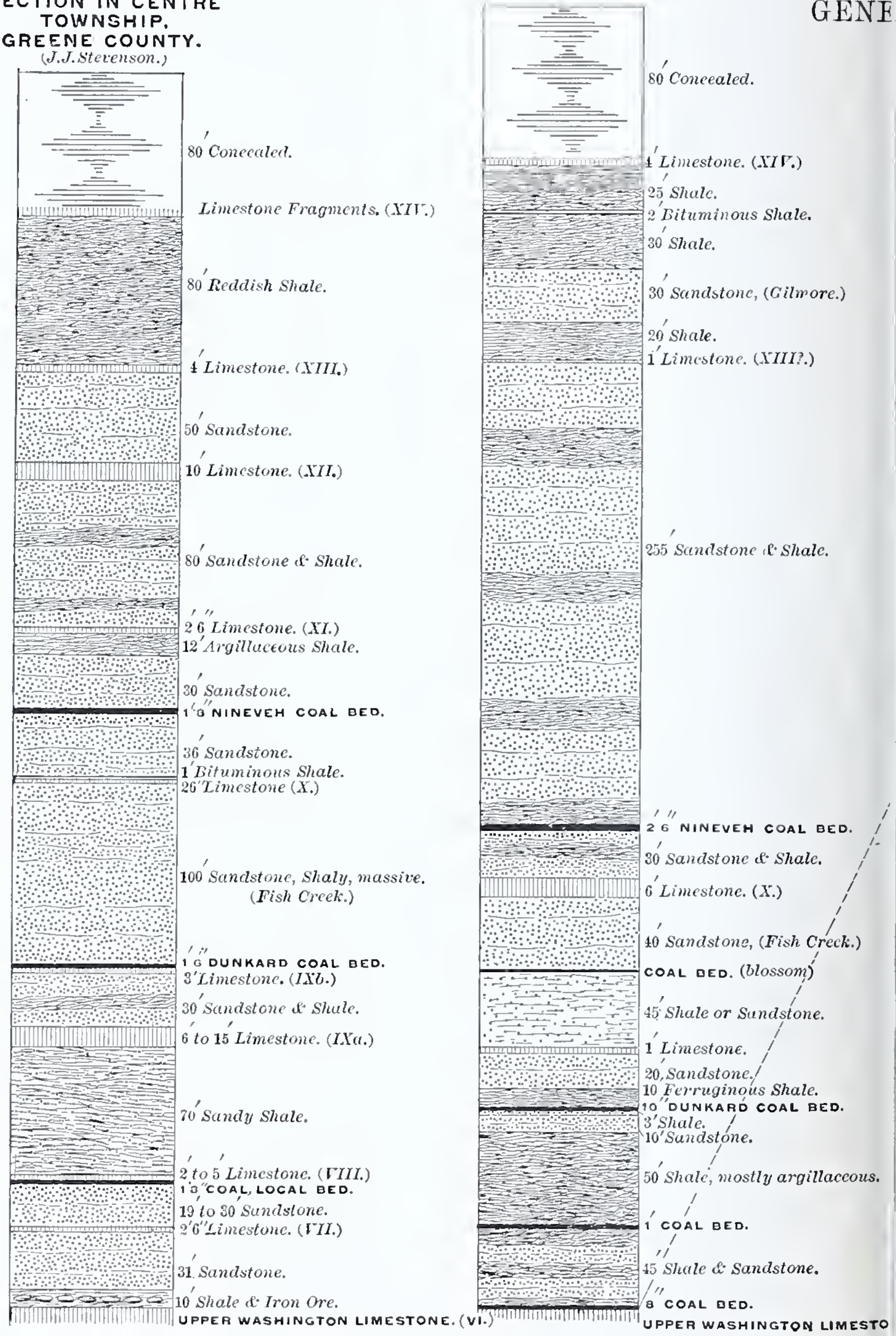
*Geology of Pittsburgh Coal Region ; Transactions Am. Inst. of Mining Engineers, Vol. XIV.

GREENE COUNTY GROUP.

SECTION IN CENTRE TOWNSHIP, GREENE COUNTY.
(J.J.Stevenson.)

SECTION ON FISH CREEK.
(J.J Stevenson.)



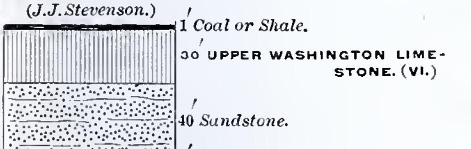
GENEAL

ALISED SECTIONS OF THE UPPER BARREN MEASURES IN GREENE AND WASHINGTON COUNTIES.

WASHINGTON COUNTY GROUP.

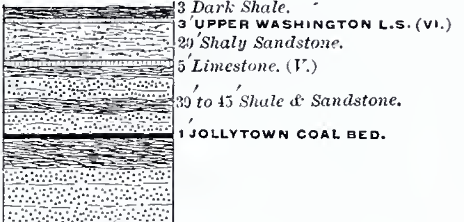
SHINGTON COUNTY.

(J.J. Stevenson.)



GREENE COUNTY.

(J.J. Stevenson.)



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Lithologically considered, the characteristic features of the Upper Barren Measures as a whole are:

a. The absence of workable coal beds.

b. The presence of seventeen different limestone beds. The most persistent one of these, called the *Upper Washington limestone*, and adopted as the division-line between the two groups, is persistent throughout the region and may be called 30 feet thick. To the geologist this limestone is as important for identifying his sections of the Upper Barren Measures, as the Ferriferous limestone has long been in the study of the Lower Productive Coal Measures; although measurements made from its top upward in Greene county, and from its base downward in Washington county, cannot be so well relied upon on account of the variable stratification of both groups already mentioned.

c. A number of sandstone deposits characterize the Upper Barren Measures, the highest of which, near the top, is 50 feet thick; another, somewhat lower down, 60 feet thick, holds the thin Nineveh coal; and a third, called the Fish Creek sandstone, immediately underneath the last, is 100 feet thick. In the Washington group a sandstone deposit 80 feet thick contains in its middle the thin Jollytown coal bed, and at the bottom of the group is a sandstone 30 feet thick. These sandstones mark the topography of the country strongly in different localities, but they cannot be used as good guides to the structure on account of the rapid local changes to which they are subject. In this they differ considerably from the great sandstones of the Lower Productive Coal Measures, especially the Mahoning sandstone, and the sub-divisions of the Conglomerate, although these latter are themselves locally very variable. The contrast, however, must not be insisted on too strongly, considering the comparatively small area over which we can examine the upper sandstones, and the immense area over which, and in every locality of which, the lower sandstones have been minutely studied. If it were possible to replace the Upper Barren Measures in their whole original outspread over western Pennsylvania, perhaps these sandstones also might be found to be, barring local variations, quite as widespread and persistent as those of the bottom series. On the other hand, the probability of their being actually more local is increased by the fact that the Upper Barren Measures of which they form parts seem, when taken as a whole formation, more variable both in thickness and in the character of rocks than the underlying earlier deposits.

d. Another prominent feature of the Upper Barren Measures is the red shale formation, near their top, which measures 80 feet in thickness, and colors the soil of the extreme highland of Greene county, suggestive of the Permian strata.

e. Although the term Upper *Barren* Measures is justified by the fact that the thinness of the few coal beds which exist makes them practically worthless, two of these coal beds, lying near the bottom of the formation, are really valuable. The Washington coal bed and the Little Washington coal bed lie only 10 or 20 feet apart. In Washington county the upper bed is 10 feet thick and the lower bed 1 foot, a 10-foot sandstone parting them. Traced into Greene county, the big bed dwindles to 2½ feet and the little bed swells to 7 feet, and there 18 feet of soft sandstone and clay separate them.

The intercalated sandstones pass into shales, and the shales into sandstones, from township to township. The numerous limestones are thin and variable. The coal beds are almost too thin to be mined, and generally make no obvious mark upon the ground. The compiled column, obtained by a close survey of the northern part of Greene county was found scarcely applicable in the southern townships, and differed materially from that in Washington county.

It must not be supposed that the Upper Barren measures are confined to the country west of the Monongahela river. They formerly extended over Fayette and Westmoreland counties. The highest hills east of the Monongahela river, along the synclinal lines in Westmoreland and Fayette counties, are capped by these Upper Barren measures.

But while in Greene 1100 feet of them have been preserved (*i. e.* more than 700 in the Greene county group, and something less than 400 in the Washington county group), the greatest thickness of any of the patches left in Fayette county is only 660 feet. The Washington bed on that side of the river has a maximum thickness of 10 feet ; but with a character so extremely variable, and shale partings so numerous, as to make it nearly worthless.

The palæontology of the Upper Barren measures, when studied, will be very interesting. The uppermost (14th) limestone contains occasional fish-scales. The 10th limestone breccia has a shale roof with plants and occasional fish-scales. The 6th or large snow-white Upper Washington limestone is roofed by a black shale containing vast numbers of bivalve crustaceans and fish-scales, all well preserved, and is often crowded with the long slender leaves of *sigillaria medardi* (?), as best seen at the tunnel east of Washington. *Calamites* are also abundant, but only a single fern leaflet (*Neuropteris*) was seen. In a middle dark band of this limestone great numbers of little bivalve crustaceans are well preserved ; they are, however, common to all the limestones of the series. In the lowest fetid layer of this limestone are broken fragments of mollusks. The 4th or ferruginous limestone is rich in calcspar replacements of minute *Bellerophon* and *Euomphalus ;* while branching *bryozoa* cover its weathered surface. A fish-tooth (*Diplodus ?*) has been found in it, and a fine spine of *Ctenacanthus marshii*, 5 inches long. The 3d limestone has a black shale roof with many lamellibranch shells, and fish-scales, some of which are large *Rhizodus*. The 2d limestone has a black shale roof rich in bivalve crustaceans and fish-scales, with an occasional macreated leaf.

Additional facts concerning the commercial aspects of these measures will be found in the succeeding chapters on the geology of Greene and Washington counties.

The Upper Productive Coal Measures.

The various members of this important series occupy a large portion of the region under discussion and with the great coal bed marking the base of the system, the map coloring of their outspread fairly shows the limits of the present *commercial* areas of the Pittsburgh Coal Region. While necessarily existing wherever the higher Upper Barren Measures are shown on the map, they are generally buried from sight in such places, and comparatively little is known of them except from records of the deep wells recently bored for gas and oil through the overlying strata.

But these rocks are well exposed along the Monongahela river from Pittsburgh to the West Virginia line, and up the Youghiogheny from McKeesport to the Fayette axis, dividing the gas and coking-coal fields. It was therefore named by Prof. Rogers the *Monongahela River series.*

These rocks create all of the immediate river topography, for their top members never pass beneath water level nor their base out of the average hill top; they form cliffs and bluffs for the greater charm of the tourist and to the increased satisfaction of the geologist; and these sections are repeated in a thousand branch streams and minor ravines throughout the 90 miles of river front between Pittsburgh and the Cheat river, and up that river into West Virginia.

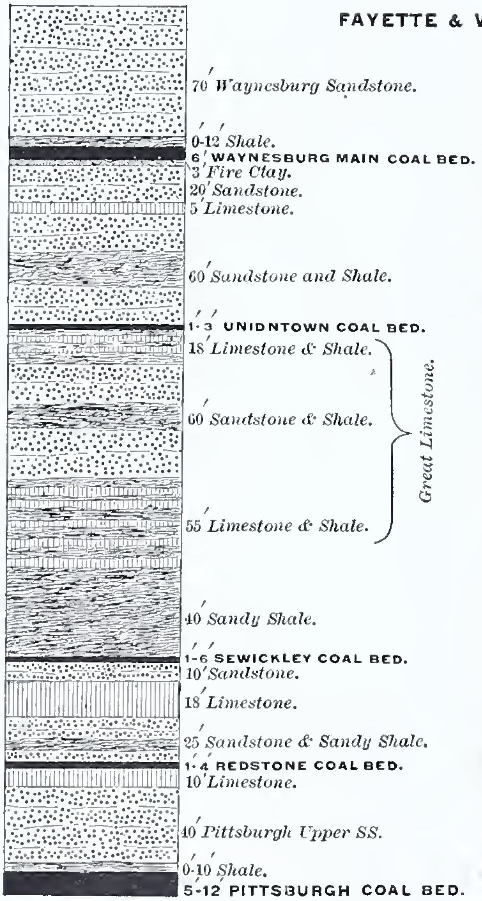
The series holds five coal beds, all of them persistent as to horizon, but only one of them, the *Pittsburgh bed*, persistent as to quality, availability and thickness. All these requirements of a first class commercial coal bed, this magnificent deposit meets in every particular, and in reviewing the sudden and apparently unaccountable fluctuations in the other rocks and coal beds of the district, it is really marvellous to note the constancy and excellence of this great *Pittsburgh coal bed.*

Every observer, however, in this field has found out quickly that he cannot use tape lines to locate the horizons of the higher coal beds of this series, and indeed the group is subject to so many variations throughout the wide outspread in the different coal basins, that it is difficult to present anything but an approximation of the truth, showing the extreme development of the series as a whole. The following sections given in the various reports of the Sur-

GENERALISED SECTIONS OF THE UP
FAYETTE AND WESTO

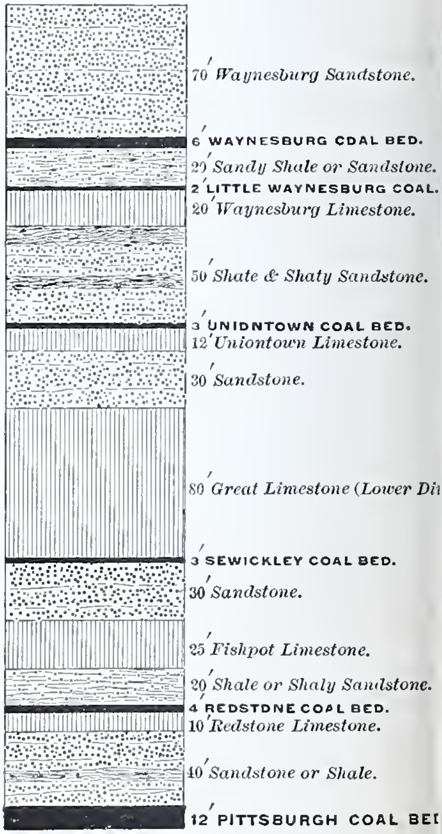
MONONGAHELA RIVER

(*Stevenson.*)



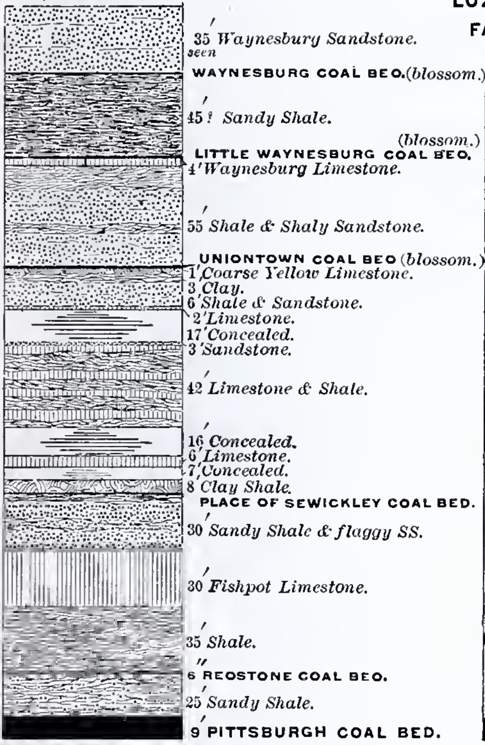
FAYETTE & WESTMORELAND COUNTIES.

(*Stevenson.*)

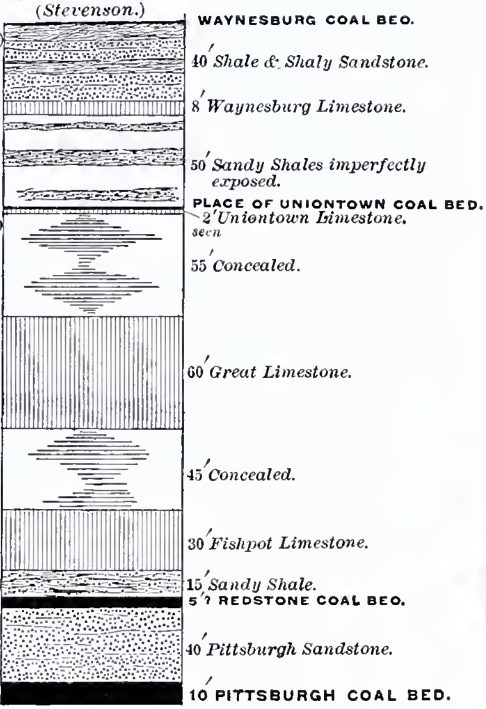


R PRODUCTIVE COAL MEASURES IN
RELAND COUNTIES.

UNLAP'S CREEK,
AYETTE COUNTY.
(*Stevenson.*)



LUZERNE TOWNSHIP,
FAYETTE COUNTY.
(*Stevenson.*)



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vey, are brought together here for comparison, and do not need descriptive text. (See accompanying plate.)

To treat of the coal beds first, and in order downwards, the *Waynesburg Main Coal Bed* is almost unknown to the farmers in Allegheny county; it is scarcely more important in Washington county, and is likewise exceedingly thin (though of good quality) in the Lisbon basin of Westmoreland county. Its maximum thickness in the counties mentioned may be set at 3 feet.

In Greene and Fayette county it attains its chief development, and is largely a source of supply to the local trade originating in the different settlements through these counties. It is not mined for shipment, however, and at times shows great variations in thickness. It is usually a double or triple bed, though sometimes still further sub-divided.

In Greene county, and perhaps eastern Washington, (except along the river,) it is the chief source of supply.

It is quite as largely mined at country pits in southern Fayette, in German, Luzerne, Brownsville and Redstone townships; is usually triple in character, and thins northward. The variations in thickness are no less violent here, showing from 2 to 5 feet generally, with bands of clay included.

The *Uniontown coal* is persistent as coal or bituminous shale throughout the district wherever its horizon is reached. It is more frequently shale, nowhere reaching mining thickness except in the merest local spots, and can be dismissed from a general discussion of the coal beds of the series.

The *Sewickley coal bed* is quite similar to the Waynesburg in point of production, area and persistency.

Its horizon can be recognized nearly to the Allegheny county line in Washington county, and in Westmoreland county can be carried as far north as Sewickley creek. But except in south-eastern Greene and south-western Fayette, it can hardly be called an available coal bed. In these latter districts, it is known as the "Five-Foot Seam;" it is mined on Dunkard and Whiteley creeks 5′ 6″ to 4′ 6″ thick; usually double or triple, and furnishing fairly good fuel.

In Nicholson and German townships of Fayette county, it has been largely mined also, but only for local use. It is from 3 to 5 feet thick there, while only about 3 inches in Perry township on the Youghiogheny.

The *Redstone coal bed*, occurring usually only 40 to 60 feet above the Pittsburgh, has an outspread through the district practically as extensive as that bed. It is persistent, too, in one form or another; can be found all along the two rivers; through southern Allegheny, western Washington; along the Panhandle R. R and south-eastern Greene.

In Fayette and Westmoreland it is generally present in the Lisbon trough far beyond the Penna. R. R.

Along Dunkard creek, in Greene county, it shows only a bituminous shale 1 foot thick and a few inches of coal. The amount of coal increases going down the river to Greensboro', where the shale is also thickest, the latter thinning northward to Whiteley creek. Its variations down the river are peculiar and erratic, and will be spoken of in detail in discussing the township geology bordering the Monongahela.

North of West Elizabeth, in Allegheny county, it was not noticed. In western Washington county it is likewise very variable and frequently obscure, and never of any importance as a coal bed.

In Fayette county it is a carbonaceous shale, 4′ thick. It shows only 1 foot of coal at Brownsville and Redstone, 4′ again in Washington township, along the river, and simmering down to 2 feet in Perry township.

In Westmoreland, it swells to 4′ on the Youghiogheny; the same on the Sewickley; 3′ on Little Sewickley, and thinning decidedly northward.

Where large enough to mine, the coal shows a fair quality, not very sulphurous but high in ash. Moreover the bed is usually so seriously troubled with "rolls," "horsebacks," and "clay veins" as to discourage systematic work everywhere and confine the coal entirely to the local demand which naturally springs up around the most available coal bed in a township.

Occasionally other coal streaks intervene in the interval between the Waynesburg and Pittsburgh seams, but they are fairly local and insignificant. It remains only to briefly repeat some of the well known characteristics of the *Pittsburgh bed*, its general position in the field, and some comparative sections of its component divisions in different parts of the field.

The *Pittsburgh bed*, as an inspection of the colored map will show, is almost entirely confined to the country south of the Ohio river in the region under discussion. East of Pittsburgh narrow areas of this bed are still left in Allegheny county north of the river and the Pennsylvania railroad; but they are insignificant, under light cover, and mainly worked out.

After crossing the Murraysville anticlinal and entering the Irwin coal basin, the outcrop of this bed extends well northwards to the Kiskiminetas river, but outside the scope of this report.

But even considering its outspread in this and the Blairsville trough, the scattered remnants of this bed remaining on the high hill tops in north Allegheny, Indiana and Armstrong counties are but islands spared by the destructive floods and erosion of past ages, left behind as monuments to the great area formerly occupied by this noble bed.

But while it has been estimated* that the State of Pennsylvania probably possesses but 1 per cent. of the coal which once existed within her State lines, the Pittsburgh region, through the possession still of a vast domain of territory underlaid by this one superior coal bed, has really suffered less than any other part of the State.

It has already been shown in Chapter II how largely the region owes its commercial prosperity to the presence of this bed, always accessible along the main river and railroad lines; always of persistent and regular mining thickness; always of superior quality, and from various contiguous basins, able to supply any demand upon it for quantity or for the special purposes of coking, gas or steam coals. This undeniably good character of coal, low in ash and sulphur, and varying chiefly in the relative percentages

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***Prof. J. P. Lesley, Trans. Am. Institute Mining Engineers, Vol. XIV.**

of volatile matter and fixed carbon, and in the physical structure of the bed, will always command for this bed, the respect and attention of the commercial world, at home and abroad, no matter what brief reactions may be caused by the transitory utilization of petroleum and natural gas.

Of one thing there seems to be no question, viz: that the mining and utilization of Pittsburgh coal will be conducted on a far larger scale in future time, long after the brilliant lights of its now favored rivals shall have ceased to cast shadows; and that here, in this abundantly supplied district, will this mighty industry most flourish.

The following ample description of the prevailing characteristics of this bed are reprinted, with some few changes and additions, from the report of 1875, K., page 70:

With rare exceptions this bed is double, consisting of a roof and a lower division, separated by a clay parting, which varies in thickness from one-fourth of an inch to nearly three feet, and frequently contains thin strings of coal which are connected with the roof division.

Where the structure is completely exposed, there is seen resting on the roof a bituminous shale, 8″ to 12″ thick, always laminated, and having a fracture like that of the poorer cannels; it is not persistent in the southern portion of the district.

The Roof Division shows extreme variations. Its thickness is from two inches to eight feet, but there is a distinct increase in thickness northward. Occasionally it is a single bench; but commonly it contains two or more benches of coal, separated by clay; and at one locality it is broken into twenty divisions. The coal is invariably poor, owing to the large proportion of ash. The clay partings are subject to abrupt variations, for on the Panhandle railroad the roof shows twenty divisions at a little distance east from Raccoon station, while at the station it shows 5′ of coal broken only by partings so thin that they can hardly be distinguished on the weathered surface. The changes in thickness of the whole division are equally abrupt, several instances having been observed where within a short distance it varied from a single 2″ bench of coal to a mass of coal and shale 3′ thick. This coal is never mined.

It has just been said that this roof-division thickens northward. This statement is the result of many comparisons; for if one were permitted to select examples he could without difficulty find many cases in Allegheny and northern Washington and Westmoreland where the roof is as thin as at any place in Greene or south-eastern Washington or Fayette. But taking all the measurements in the south-eastern portion, and comparing them with all those made in the northern portion, it becomes apparent that the roof is thicker northward, and that in north-western Washington and Allegheny the thickness is suddenly and greatly increased.

This statement will appear more clear perhaps upon a comparison of the vertical sections of this Pittsburgh coal opposite, selected at random but from widely different parts of the field. Such sections will also make more plain the description, to follow immediately, of the subdivisions of the main or lower bench, from which all the commercial coal of the Pittsburgh region is mined.

The *Lower Division* of the Pittsburgh coal is from 3½ to 9 feet thick, and shows always three persistent slate partings, which divide it into four distinct benches, known as the "Upper or Breast Coal," the "Bearing-in Coal," the "Brick Coal," and the "Lower Bottom Coal."

In the first or *Upper Bench*, there is occasionally a parting which is rarely seen except at the extreme north-west, where it seems to be a common feature. This is the thick bench and usually yields the best coal.

The "*Bearing-in*" *Bench* varies from 2″ to 4″, and is invariably distinct, except where the bed is a block coal, and all the partings are missing. The name is applied because on this bench the miner works in to gain a face against which to bring out the other portions of the bed. This is generally a good coal, but in removal it is reduced to slack.

The "*Brick*" *Bench* is characterized by cleavage planes which break the coal into blocks in size and shape like a common brick, whence the name. It yields a good coal, hardly inferior to that from the Upper Bench.

The "*Lower Bottom*" *Bench* is the lowest of all, always of inferior quality, and for the most part utterly worthless. It is broken by numerous thin layers of clay, as well as by cleavage planes, so that it is brittle, and full of ash.

The Upper Bench contains thin partings or binders of pyrites, one of which, at from ten to fifteen inches from the top is quite persistent. This impurity sometimes occurs in the Brick, and is always present in the Lower Bottom.

The thickness of the whole Lower Division of the Pittsburg bed diminishes northward, as the Roof Division seems to increase in that direction; but, with the exception already noted, the various benches are persistent throughout. In the south-eastern part of the district the total thickness is from seven to nine feet; greatest at Brownsville, where the roof is 4″ and the lower division is 9′. In the vicinity of Pittsburgh and the adjoining portions of Allegheny county, it varies little from 5′ 6″; while in north-western Washington, it varies from 3′ 6″ to 5′; the former (3′ 6″) being found at Midway on the Panhandle railroad, where the coal is a block.

In the Lisbon-Irwin basin, of Westmoreland and Fayette counties, it is still a double bed, and the variations from south northward are shown by the following tabular statement, (KK, p. 59):

LOCALITY.	Roof division.	Main clay parting.	Lower division.
Spring Hill township, Fayette Co., ...	4′ 0″	0′ 6″	8′ 6″
Nicholson " "	6′ 0″	0′ 5″	8′ 3″
Brownsville " "	0′ 4″	0′ 6″	9′ 0″
Franklin " "	3′ 0″	0′ 8″	7′ 0″
Perry " "	2′ 0′	0′ 8″	7′ 0″
Rostraver township of Westmoreland Co., . .	2′11″	1′ 0″	8′10″
South Huntingdon twp. of Westmoreland Co.,	2′ 8″	1′ 0″	7′ 5″
Sewickley " "	4′10″	0′10″	5′10″
North Huntingdon " "	2′ 1″	1′ 0″	6′ 6″
Penn " "	3′ 0″	1′ 3′	6′ 0″
Salem " "	2′ 0″	0′10″	7′ 8″
Loyalhanna " "	3′ 0″	1′ 0″	8′ 6″

Of course such measurements and representations are merely the general averages, but they are sufficient to show there is no more *uniformity* in the thickening of the roof division northward in this basin, than in the troughs lying further west across the Monongahela.

The division of the lower part of the bed into the separate benches already enumerated, is fairly well maintained here, being slightly indefinite in Nicholson and Spring Hill townships, along the crest of the Fayette axis, and at Brownsville, where the whole bed is almost a block coal, similar to that mined along the Panhandle railroad and on Thoms run.

In general, throughout the district, it may be said that the coal from the Lower Division of the Pittsburgh bed is somewhat brittle, caking, rich in volatile combustible matter, and containing a variable percentage of sulphur. In some portions of the district, it exhibits layers of cannel near the top and occasionally, as along the Panhandle railroad in Washington county, it becomes a very superior *block coal.*

The character of the Pittsburgh in all the markets of the country is too well known to require separate mention here. Suffice it to say that the average of thousands of analyses has shown it to contain from 58 to 64 per cent. of fixed carbon; 30 to 35 per cent. volatile matter, with 4 to 14 per cent. of ash, the latter constituent depending largely upon the care in mining and cleaning the coal, as does also its percentage of sulphur, which ranges usually below 1 per cent., but occasionally rises to 2 or 3 per cent. in hard specimens and carelessly mined coal.

After the distinctive character given this group by reason of its fine coal beds, each one of which becomes of available thickness and quality in its own separate part of the field, the prevailing feature of the Upper Productive (Monongahela) coal series lies in its limestone rocks.

The combined thickness of the various limestone beds of the group aggregate nearly one-fourth of the whole series, and in that respect it far outstrips all other divisions of the coal measures for the same thickness of rocks.

The first of these, and the uppermost, is the *Waynesburg limestone,* which occurs in the interval between the *Waynesburg* and *Uniontown* coals. It is present in all of the troughs of the district, wherever its horizon is reached, though to some extent absent in local parts of different basins, where its place is filled by sandstone or sandy shale. Its position is usually from 20 to 40 feet below the upper coal, and varies in thickness from 8 to 35 feet, everywhere yielding a lime of superior quality. A description of its local character and thickness in the various portions of the region, will be found in the special geology of the different townships.

The second limestone in descending order, but the chief one of the Upper Productive Series, is the *Great Limestone*, occupying, with its sub-divisions, the entire interval between the *Uniontown* and the *Sewickley* coal beds.

Ordinarily this deposit shows three distinct divisions:—an *upper division* of limestone 6 to 18 feet thick; a *middle division* of sandstone and shale 30 to 40 feet thick, and a *lower division* of limestone 50 to 60 feet thick.

But for greater convenience it has been thought best to incorporate the entire formation into an *upper* and *lower division*. The *Upper Division of the Great Limestone* varies from 6 to 18 feet west of the Monongahela, and from 6 to 15 feet thick in the Lisbon trough of Westmoreland and Fayette county, where it has been identified as far north as North Huntingdon township.

The quality here is as variable as the thickness; sometimes the bed yields a lime of excellent quality, at others it is worthless, while again it produces a very fair cement. It is absent in Allegheny county, west of the Monongahela. The Lower Division of the Great Limestone is very persistent, varying from 50 to 90 feet, and attaining its greatest thickness in the Lisbon trough. Here, however, it thins northwards, loses its importance along the Penna. R. R. around Irwin's, and becomes subject to great and sudden fluctuations.

"The lower portion is commonly more or less *magnesian*, breaks with a smooth surface, which is sometimes lusterless, while at others it is quite bright. This part is employed for the manufacture of *cement* at many places, and is available throughout eastern Washington county. It is the more persistent part of the mass, having been identified in Allegheny county, on the Pittsburgh and Steubenville pike. When exposed to the weather it eventually breaks up into small angular fragments. Its thickness is sometimes fully 50 feet, nearly all of which is limestone. The relative proportion of shale increases northward, and in Allegheny county the shale seems to predominate. This portion is wholly *non-fossiliferous* except in a thin layer at the base. The upper portion contains every variety of limestone, from that pure enough for the manufacture of lime, to that which is utterly worthless for any purpose whatever."

The *Fishpot limestone* is next calcareous stratum, occurring in the interval between the *Sewickley* and *Redstone* coals, flanked above and below by beds of sandstone.

"Along the river line in Washington and Greene counties, this limestone shows some interesting variations. Beginning at the West Virginia line, it is quite thin; thence it increases to the mouth of Fishpot run in southern Washington, a little beyond the trough between the Fayette and Waynesburg axes. There it is 30 feet thick.

"From this locality it diminishes and at length disappears before reaching the summit of the Waynesburg axis.

"From this line northward along the river, the interval between the two coals is occupied by sandstone or sandy shale. Between the Pin-hook and Washington axes, limestone occurs in this interval as far north as the southern portion of Allegheny county, but beyond Upper St. Clair township of that county, it seems to be filled with sandstone. In the trough west from the line of the Claysville axis, the limestone is persistent as far north as the Steubenville pike in Allegheny county. Whether it reaches farther north cannot be determined, as there are no exposures."

In the Lisbon trough, towards the southern portion, this limestone is usually separated from the overlying *Sewickley* coal by only a few feet of sandy shale, and occasionally the coal rests directly on the limestone, as at New Geneva. On Cats' run, 4 miles north, the interval is 15 feet; on Redstone creek 30 feet; on the Youghiogheny 20 feet. On the

Redstone it is 30 feet thick, and of excellent quality; on the Youghiogheny it is 10 feet thick and impure; and again in South Huntingdon township of Westmoreland county it shows 20 feet thick, and pure.

It is more persistent along the eastern side of the Lisbon basin than on the river side; but it disappears before reaching Sewickley creek and cannot be identified further north.

On the west side it cannot be distinguished beyond the Youghiogheny river.

Another interesting feature of the Upper Productive or Monongahela River Series is the great sandstone formation at its top, known as the *Waynesburg S.S.* The rock is massive, soft, weathering to honey-combed surfaces, and sometimes difficult to distinguish from the almost equally imposing *Pittsburgh sandstone* occurring much lower, and over the Pittsburgh coal. It attains its greatest development in Greene county, where it is not far from 70 feet thick, and shows two nearly equal divisions, separated by sandy shale.

It is also quite persistent in the Lisbon trough as far north as its horizon occurs.

Towards the south, it is commonly compact below and flaggy above, but at some localities on the river bluffs in German and Luzerne townships, the whole mass forms cliffs of solid sandstone, well fitted for building purposes. It is here from 65 to 70 feet thick.

3. *The Barren Measures.*

Under this name the First Geological Survey included all strata lying below the *Pittsburgh Coal bed*, down to the *Freeport Coal bed.* Most of the reports of the Second Survey take the same view, and it will be adopted by the State Geologist in his Final Report. But Prof. Stevenson, in his reports on Washington, Greene, Allegheny, Fayette and Westmoreland counties, and Prof. White, in his reports on Beaver, Lawrence and Mercer counties, found it convenient to restrict the *Barren Measures* between the *Pittsburgh Coal bed* and the top of the *Mahoning Sand-*

stone, which overlies the *Freeport coals.* Their practice will be followed in the present report to avoid confusion of terms.

The old name *Barren Measures* has been retained in common use, although in some of the reports of progress they have been called *Lower Barren Measures.* In the final report of the State Geologist they will probably be called the *Pittsburgh Series.*

The members of this series are subject to quite as great and widespread fluctuations of character and thickness as the rocks of the two higher divisions already treated of. It consists mainly of shales and sandstones, with some variable coals and limestone, rarely of any economical value.

This series is entirely buried from sight through all of Greene county, except along the immediate river front in Monongahela and Dunkard townships and on Dunkard creek, in the south-east corner of the county.

In Washington county only a portion of the series are exposed along the Monongahela river from the Allegheny county line south to West Brownsville, and to a very limited extent north and south of Fredericktown in the same county; on Peters creek, Mingo creek, Pigeon creek and Pike run, some few of its upper members are exposed; on Chartiers creek between Cannonsburg and Washington, owing to the presence of the *Washington anticlinal;* on Cross creek along the western border line; along the Panhandle railroad partially, and in the extreme north-west townships of the county.

In Allegheny county south of the Ohio river these rocks outcrop along every one of the principal streams east of the Chartiers Valley and Panhandle railroads and through five-sixths of the territory west of Chartiers creek.

North of the Ohio and Allegheny rivers, however, their presence is the rule, not the exception, and merely patches of the Upper Productive Measures cap the highest summits.

In eastern Allegheny county, in the triangle between the Allegheny and Monongahela rivers some considerable areas of the Upper Productive Measures serve to extend the outcrop of the Pittsburgh coal bed northwards to the Kiskiminetas river; but by far the greater part of this area has the Barren Measures for its surface rocks and the country so occupied is everywhere characterized by the singularly diversified topography which their decomposition gives rise to.

In the limited portions of Fayette and Westmoreland counties treated of in this report the area is about equally divided between this and the next higher series; sparingly in Fayette along the line of the Fayette anticlinal and the immediate river bluffs; more profusely in Westmoreland when in addition to the outspread of these rocks over the crest of the Saltsburg anticlinal north of the Sewickley creek they cover continuously all north-western Westmoreland county, west of the Lisbon basin and over the Murraysville-Roaring Run axis to the Allegheny river.

The series of four vertical sections given in accompanying plate will sufficiently describe the character and sequence of the various rock members constituting this group:

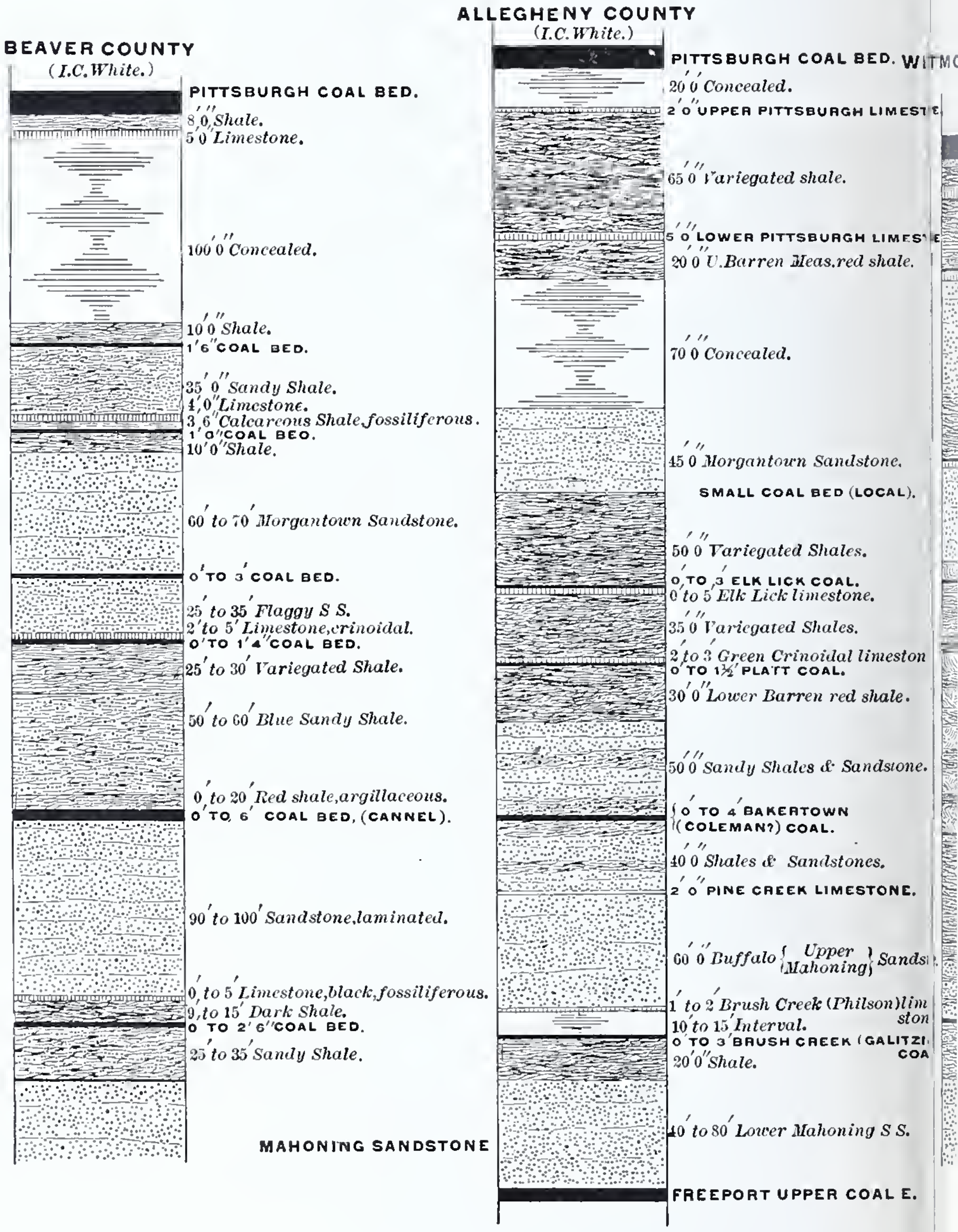
"The extreme thickness *exposed* along the Monongahela is 375 feet, this being reached only near the West Virginia line and at Pittsburgh. In Allegheny county away from the river, and in Washington county north from the Panhandle railroad, this thickness is occasionally shown. Throughout Greene, away from the river, and in the greater part of Washington the Lower Barrens are deeply buried. The whole series is seen in detail only in Beaver county, where owing to the predominance of sandstones the exposures are good and clear.

In the south-eastern portion of the district, as shown by oil-borings on Dunkard creek, the interval between the *Pittsburgh Coal* and the Mahoning sandstone is not far from 425 feet; but this interval increases northward and north-westward." K, p. 76.

The group, as constituted, includes three principal sandrocks; the Connellsville sandstone, with an average interval of 50′ beneath the *Pittsburgh coal bed;* the Morgantown sandstone, 100 feet lower, and the (Saltsburg?) sandstone 350 feet beneath the *Pittsburgh coal.*

But these sandstones, like all the members of this group,

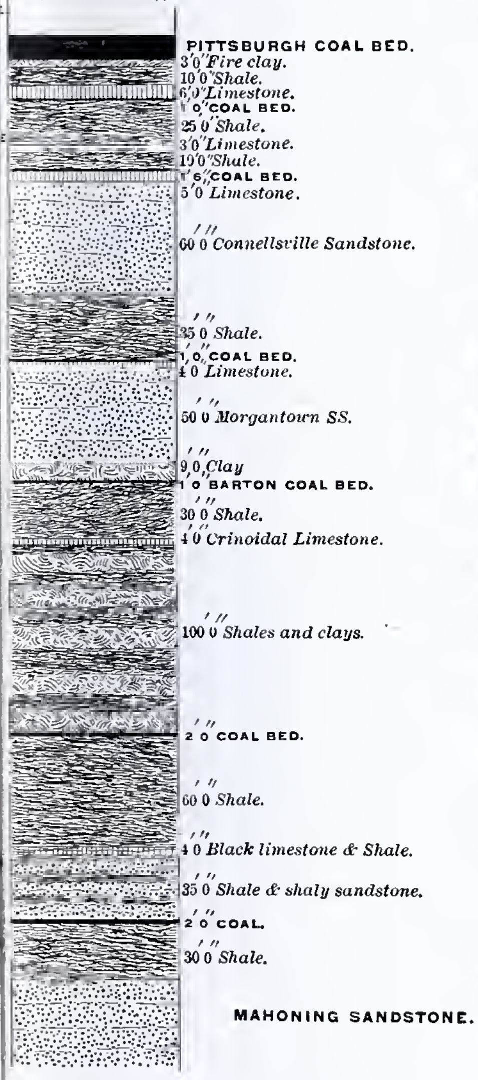
GENERALISED SECTIONS OF THE LOWER B
WESTMORELAND AN


BEAVER COUNTY
(I.C. White.)
PITTSBURGH COAL BED.
8' 0" Shale.
5' 0" Limestone.
100' 0" Concealed.
10' 0" Shale.
1' 6" COAL BED.
35' 0" Sandy Shale.
4' 0" Limestone.
3' 6" Calcareous Shale, fossiliferous.
1' 0" COAL BED.
10' 0" Shale.
60' to 70' Morgantown Sandstone.
0' TO 3' COAL BED.
25' to 35' Flaggy S S.
2' to 5' Limestone, crinoidal.
0' TO 1' 4" COAL BED.
25' to 30' Variegated Shale.
50' to 60' Blue Sandy Shale.
0' to 20' Red shale, argillaceous.
0' TO 6' COAL BED, (CANNEL).
90' to 100' Sandstone, laminated.
0' to 5' Limestone, black, fossiliferous.
9' to 15' Dark Shale.
0 TO 2' 6" COAL BED.
25' to 35' Sandy Shale.
MAHONING SANDSTONE
ALLEGHENY COUNTY
(I.C. White.)
PITTSBURGH COAL BED.
20' 0" Concealed.
2' 0" UPPER PITTSBURGH LIMEST
65' 0" Variegated shale.
5' 0" LOWER PITTSBURGH LIMES
20' 0" U. Barren Meas. red shale.
70' 0" Concealed.
45' 0" Morgantown Sandstone.
SMALL COAL BED (LOCAL).
50' 0" Variegated Shales.
0' TO 3' ELK LICK COAL.
0' to 5' Elk Lick limestone.
35' 0" Variegated Shales.
2' to 3' Green Crinoidal limeston
0' TO 1½' PLATT COAL.
30' 0" Lower Barren red shale.
50' 0" Sandy Shales & Sandstone.
0' TO 4' BAKERTOWN (COLEMAN?) COAL.
40' 0" Shales & Sandstones.
2' 0" PINE CREEK LIMESTONE.
60' 0" Buffalo {Upper Mahoning} Sands
1' to 2' Brush Creek (Philson) lim ston
10' to 15' Interval.
0' TO 3' BRUSH CREEK (GALITZ COA
20' 0" Shale.
40' to 80' Lower Mahoning S S.
FREEPORT UPPER COAL E.

RREN MEASURES IN BEAVER, ALLEGHENY, FAYETTE COUNTIES.

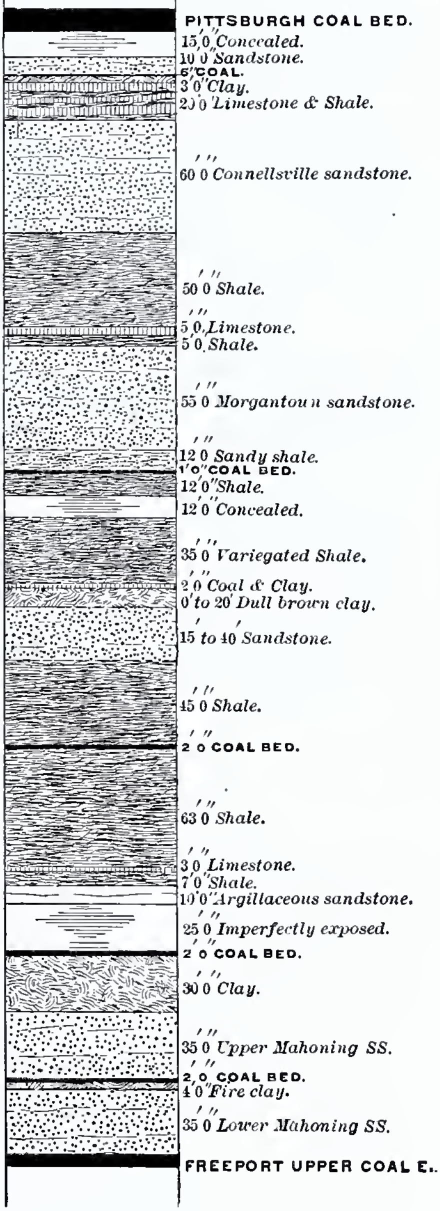
MORELAND COUNTY.

(J.J. Stevenson).



DUNBAR CREEK, FAYETTE CO.

(J.J. Stevenson).



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while persistent as a whole throughout the region, thicken and thin and pass into shale, so that they cease to become safe geological landmarks or key-rocks within very brief distances.

The limestones of the Barren Measures are chiefly near the top; they are thin and commercially worthless, though two of them are important guides to the geology above and below them, and are invaluable in a series so bereft of other persistent and well-recognized rocks.

These are the *Crinoidal limestone* at 250–300 feet beneath the Pittsburgh coal; and the *Black limestone* occurring at about 100 feet above the base of the series.

The first limestone met with occurs at an interval of a few inches to 8 feet beneath the Pittsburgh coal, and is the rock so frequently seen throughout the various mines of the district in the bottom of drains. It is a coarse, sometimes brecciated limestone, light blue to gray in color. Below this, 10 to 30 feet, there is another quite persistent limestone distinct in the south-eastern portion of the district, but absent in north-western Washington and western Allegheny.

Toward the base of the concealed interval of the Beaver section there are two limestones which were seen on the Panhandle railroad west from Mansfield, and on the Chartiers Valley railroad south from that place. Evidently these are wanting along the Monongahela river. They are quite ferruginous, and each is fossiliferous.

The *Crinoidal limestone* is the next persistent stratum, occurring beneath the great Morgantown sandstone formation, though separated from it by the *Birmingham shales*, a prominent feature of the Coal Hill bluff opposite Pittsburgh, where it shows a jointed mass of thinly laminated shale nearly 50 feet thick, and reaching its main development there. The Crinoidal limestone is the Green Fossiliferous limestone of the old reports. It is 2 to 4 feet thick, and has been found of so much utility in a geological study of the region, as a universal key-rock or base of vertical measurement. Small as it is, it is found at so many distant localities, and is so easily identified by its multitudes of crinoidal disks, spines and shells, that it would be well for every mining engineer in the region to become acquainted with it. Well-sinkers can use it in the same manner, as they have grown accustomed to use the Ferriferous limestone in the oil-region.

It has a dark greenish gray cast usually, is tough, and breaks with a granular surface. It weathers slowly into blocks. The rock is largely present in Westmoreland county, though not in Fayette west of the Fayette axis.

Along the Ohio river, from Nimick's station to Birmingham, this stratum is constantly in sight, but there it differs strangely from its common structure. The limestone is of irregular thickness, sometimes embedded in a black calcareous shale, extremely rich in fossils, while at others it forms a rude shapeless mass of limestone, 6 to 8 feet thick. At a short distance up the Monongahela river, the usual character is resumed, so that at Six-Mile ferry, Braddock's station, Peter's creek and other localities, it is as described above. It passes under the river near Peter's creek and is not exposed again within the district, though its horizon is reached below the State line.

As for the coal beds of the Barren Measures, taking the whole region into account, they amount to nothing; but, thin and poor as they are, and sometimes disappearing from view altogether, they seem to occupy regular positions in the column; this, however, cannot be absolutely demonstrated, because a connection between the numerous exposures is often impossible. The question is a purely theoretical one, and of no importance in a practical estimate of the wealth of the region.

The *Little Pittsburgh coal* is frequently noticed along the Monongahela river south of Port Perry, on Chartiers creek in Washington county, and near Mansfield in Allegheny, always about 15 to 25 feet beneath the larger and upper bed. It is also largely present in such parts of the Lisbon basin in Westmoreland and Fayette as its horizon is met with, but always thin. Another insignificant and variable thin coal is seen about 50 or 60 feet lower, along the river in south-east Greene, on the Panhandle R. R. at Nimick's and in a few other places locally.

The *Barton coal bed*, 100± feet lower, is never of economical thickness, but is very persistent in Westmoreland and Fayette, 6 to 18 inches, and good coal; locally in north-western Allegheny county, beneath the Morgantown S. S.

Two other coal beds occur in the interval of 150 feet beneath the Crinoidal limestone, but they are so thin, variable and in places altogether absent, that their horizons cannot be fixed with any definiteness whatever.

A fifth coal is occasionally found in the immediate interval above the Mahoning sandstone, present in widely separated parts of the district, but not continuously so.

Another feature of the column of Barren Measures is a deposit of red, variegated, and bluish sandy shales, 100 feet thick, underlying the Morgantown sandstone. Although the strongly red layers of this shale formation form but a moderate part of it, they make a great mark upon the country. These red shales are cut at the Pennsylvania railroad summit, a few miles north of the city. In many parts of the region the red color is not so noticeable; but in the district immediately surrounding Pittsburgh the red soil is a marked feature in the landscape.

Three red shale horizons have been traced through Allegheny and Beaver counties, and in Westmoreland county—one 100 feet beneath the *Pittsburgh coal;* another beneath the Crinoidal limestone; a third above the Mahoning S. S. They can be used locally as guides to the geological formations above or below them, especially where all three are present at one locality.

The Lower Productive Coal Measures.

These are by Prof. Rogers called the *Allegheny River Series.* They lie far under cover through most of the district, and therefore need not be treated of in the same detail accorded the preceding groups.

They are at least 200 feet beneath the river at Pittsburgh, and rising north-eastward in obedience to the same laws governing the higher measures, they make their appearance in the bed of the Allegheny river below Tarentum, each successively lower bed of coal, sandstone, shale or limestone cropping a little further north than the stratum immediately overlying it.

Their insignificant exposure in the immediate district under discussion, prevents a compilation of more than a few of their top strata ; but extended sections of these and underlying measures can be found in the various published reports of the Survey on western Pennsylvania.

Of the entire series, 350′± thick, only the *Mahoning S.S.* on top, and the succeeding Freeport group of coals, limestones and sandstone occur in the *Pittsburgh coal region* proper. These upper members, in whole or in part, line the Allegheny river bluffs from Freeport to some distance below Tarentum. They are elevated to daylight along the Brady's Bend anticlinal above Millerstown, and on Pine run in Allegheny county.

In Westmoreland they show along the Kiskiminetas river ; on the Loyalhanna ; north and south of Grapeville along the crest of the Saltsburg anticlinal ; largely on Sewickley creek along the line of the South-West Penna. R. R., and on Jacobs creek, the Youghiogheny river, and the Redstone creek in Fayette county, along the Fayette axis.

The *Mahoning sandstone* is usually massive, sometimes double, carrying a small coal bed between its two divisions ; in places forming cliffs 70 feet high ; elsewhere flaggy or sandy shale, but 30′–40′ thick. On the Redstone in Fayette it is shale ; on the Youghiogheny a sandstone 50 feet thick ; so also on Jacobs creek. On the Sewickley, mostly a flaggy sandstone 40 feet thick ; shale on the Little Sewickley and sandy shale on the Loyalhanna and Conemaugh 35 feet thick.

Along the latter and the Allegheny river, it shows its typical form, massive and only a moderately coarse sandstone.

The *Upper Freeport coal* is to the Allegheny river what the *Pittsburgh coal* is to the Monongahela.

Where brought up along the Brady's Bend axis, over a small area, it is seldom less than 4′ and sometimes 7′ thick.

On the river, from Freeport to Tarentum it averages 4′ thick, but swelling up abnormally near Hitestown to 10′, with shales. In Fayette county, on Redstone creek, it is exposed for nearly 2 miles and is of workable thickness. It shows at Layton also, on the Youghiogheny, but thin and worthless.

On Jacobs creek, beneath the Fayette axis, it varies from 3 to 4 feet. On Big Sewickley creek in Westmoreland county, this bed is exposed and opened in a dozen places, as the stream winds to opposite sides of the anticlinal axis there.

The bed is broken by thin partings and varies from 2 to 5 feet. On Little Sewickley the bed is double, and greatly swollen as follows: *coal* 3 feet; clay 2′ 6″; *coal* 5 feet; total 10′ 6″.

On the Loyalhanna and Conemaugh the bed is single and varies from 3′ 8″ to 5 feet thick; and further west towards the Allegheny it shows 4 to 8 feet thick, with thin but not persistent partings.

No other members of the Lower Productive Series are exposed sufficiently for measurement and description within the *Pittsburgh district.*

CHAPTER V.

Geology of Allegheny County.

Allegheny Co. has an area of about 760 square miles. Geographically the county is naturally subdivided by its great water courses into three grand divisions:—

1. Northern Allegheny, or that part lying north of the Allegheny and Ohio rivers, and south of Butler Co.

2. Eastern Allegheny, lying south of the Allegheny river and east of the Monongahela and including the south eastern portion of the county, between the Monongahela and the Youghiogheny rivers.*

3. Southern and Western Allegheny, lying south and west of the Ohio and Monongahela rivers and between Washington and Beaver counties, which may be further sub-divided into east and west parts by Chartiers and Robinson creeks.

An inspection of Allegheny Co. on the map accompanying this report will suggest, by its coloring, a close approximation in this arbitrary division to the *geological* partition of the county.

By reference to the color scale, it will be noticed that the first division, Northern Allegheny, is occupied through nine-tenths of its area by the Barren Measure rocks, destitute of merchantable coal, and with the exception of some brick clay and building stone, without any economical features. Of the remaining tenth part of the area, which is probably too great an allowance, 90% of the surface rocks belong to the Lower Productive Measures containing the Upper Freeport coal in mining shape, and 10% to the Upper Productive Measures, with the Pittsburgh coal bed forming little isolated patches on the highest hill-tops, inaccessible but for country use, unimportant therefore from a commercial standpoint, but of vital significance as geological landmarks, proving the former outspread of this bed all through Northern Allegheny, where scarcely a vestige of it is now left, and illustrating forcibly the enormous amount of erosion that has taken place there.

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*This portion of the county, including the townships of Lincoln, Elizabeth and Forward, has been treated of in detail by the author, and especially illustrated in the Annual Report of 1885, pp. 125 to 221.

In like manner that portion of the second division, just noted, lying north of the Youghiogheny river, may be compared geologically to the western half of the third division, lying between the Pan Handle R. R. and Beaver county. Both these districts have suffered serious erosion, and in both the diversified topography of the great coal bed of the region has resulted from the carving out of great channels in it, and the underlying Barren Measures, by the rainfall of past ages. Both of these districts, though, retain more of the Pittsburgh coal and Upper Productive Measures within their boundaries than the Northern district, north of the Ohio river.

The Lower Productive Measures are nowhere exposed here, and in each district the proportion of Pittsburgh coal outcrop is about 25% as against 75% of Barren Measures. All of this coal lies high in the hills; it is, with but few exceptions, badly cut into patches, or narrow strips, and while a large amount of excellent coal has been taken from the larger areas, neither of these districts can be looked upon to furnish a large percentage of the future output or to induce the investment of large capital to develop what still remains intact.

The third geological partition of the county is readily outlined on the map. It includes everything east of the Pan Handle railroad and south of the Youghiogheny and Monongahela rivers.

It is in this district that by far the largest part of coal mining capital is invested, and the reason for this is made clear by the coloring of this portion of the county. Here the Pittsburgh coal bed underlies in round numbers 75% of the territory and only about 25% shows the Barren Measures, mainly along the river bluffs and larger streams.

Of course these percentages of productive and barren territory are merely approximate estimates; but they at once force the question: *What has caused the present unequal distribution of the Pittsburgh coal bed through different portions of the county?*

Manifestly it is unreasonable to suppose that the rainfall was any more severe in one portion of the county than in another; it is equally unreasonable to suppose the coal to have been unevenly deposited; and we know that glacial erosion did not extend this far south in Pennsylvania. A far more simple and natural geological explanation lies in the well known south-western slope of *all* the rock formations of the State from the New York line to West Virginia. This slope is exceedingly gentle, but quite persistent, and measured over large areas, amounts to about 16′ per mile.

Here in Allegheny county it is in places as high as 25 feet: that is, in traveling along a south-west line, the coal and accompanying measures are sinking from 15′ to 25′ each mile that is passed.

This fact cannot be too strongly emphasized; for on it depends largely the successful drainage of coal, where no natural outcrop exists and the future successful development of coal by shafting in the southern portion of the field.

The *Upper Barren Measures* occupy a limited portion of the field along the Washington county line at the corner of Snowden and Upper St. Clair townships, and of course a bore hole here would pierce all the measures exposed in Allegheny county and would be at least 1,200 feet deep before striking the same (Freeport) coal that crops out at the surface through portions of Northern Allegheny, as shown on the map.

1°. *Northern Allegheny.*

The geology of the first geographical district in Allegheny county can be briefly dismissed for it plays but a small part in any discussion of the Pittsburgh coal field. Besides the city of Allegheny, there are 22 townships between the Ohio and Allegheny rivers, arranged somewhat as follows:

5 Fawn,
1 Marshall, 2 Pine, 3 Richland, 4 West Deer,
7 Harrison,
8 Franklin, 9 McCandless, 10 Hampton, 6 East Deer,
18 Indiana,
11 Sewickley, 12 Ohio,
16 Ross, 17 Shaler,
20 Harmar, 21 Springdale,
13 Left, 14 Aleppo, 15 Killbuck,
19 O'Hara,

22 Reserve.

Allegheny City.

Of these, it may be said that Marshall, Franklin, Sewickley, Ohio, Left, and Killbuck drain directly into the Ohio river; the others into the Allegheny. The topography here, as elsewhere, in districts so largely occupied by Barren Measure rocks, is singularly beautiful and varied; but for that very reason it throws a mist over the structural geologist's eyes doubly trying in a region where the variation in dip is so slight as to almost debar the use of a barometer at all. Besides all this, the careful survey of this part of the region in 1876 demonstrated the variability of the great sand rock members, both in thickness and character, and introduced additional structural difficulties by reason of uncertain identification.

The erosion of all streams is nearly alike, because the same rocks in each case have been eroded, so that *geologically* speaking the surface rocks of North Allegheny can be read and studied along any one or two of the larger streams. When these streams have cut down at their mouths or along anticlinal uplifts, into the Lower Coal Measures, the massive sandstones at the base of the Barren Measures create a steep and abrupt hill side, rising from the bed of the stream. But the higher members of this group, being more shaly and yielding, have created more gentle and less forbidding slopes and rounded outlines. They are frequently quite level on top, and with the territory lying near the heads of the streams, where the erosive power is not so formidable, they make up the best farming and grazing land of the district.

Pine creek is probably the most important stream of this field, and gives an outlet to the Pittsburgh and Western R. R. Bull creek, Deer creek and Girtie's run, with their many tributaries, are likewise important streams.

The Ohio river forms the southern boundary of the district. From Pittsburgh to the Beaver line its course is north-west. At the mouth of Big Beaver, it turns abruptly south-west and so continues to the Ohio State line.

The soils of this portion of Allegheny county, being derived almost entirely from the Barren Measures, are not naturally rich, the large amount of slates, shales and sandstones and the small percentage of limestone rendering large areas sterile unless attention is paid to artificial fertilizing. The red clays of these measures are particularly tough and tenacious and hard to cultivate.

The structural features of this district have already been sufficiently described in Chap. III.

The *Brady's Bend* anticlinal is the only flexure of importance, and owing to the absence of the Pittsburgh bed throughout its course, it is not economically important. Its most useful effect has been to elevate the Freeport Coal measures along a portion of Pine creek in Hampton and Shaler townships. It sinks to the southwest about 22′ per mile.

Upper Productive Coal Series.

The only member of this series is the *Pittsburgh coal bed* whose limited area, probably not over 250 acres, has already been referred to.

At Mr. Wright's bank, in Franklin twp., the following section, quite similar to the Monongahela river mines, shows (Rep. Q., p. 22):

Upper Division,	*Coal,*	2′ 6″	6′ 6″
	Shale,	1′ 6″	
	Coal,	2′ 6″	
Main clay shale,			1′ 2″
Lower Division,	*Breast coal,*	2′ 9″	4′ 10″
	Shale,	½″	
	Bearing in coal,	4″	
	Slate,	½″	
	Brick and Bottom coal,	1′ 8″	

There is only about 30′ of cover here, and the coal is not very good. Mention must also be made of Emmitt's coal, in Pine twp., only four miles south of the Butler line, where in a high knob about three acres of the Pittsburgh bed have been preserved, just east of Wexford P. O.

The entire bed is here 10′ thick, of which amount the roof coal is 3′ 3″; main clay slate, 1′ 4″; lower division, 5′ 5″.

The Lower Barren Measures.

By reference to Chap. IV on *Stratigraphical Geology*, a compiled section of these measures in Northern Allegheny will be found, showing the Pittsburgh bed on top, and carried down so as to include the Mahoning S. S. at the bottom, showing the horizon of the Upper Freeport coal.

It is this series of rocks, 600′ more or less thick, which occupies the ravines and hill tops of this district, though in but comparatively few instances do the streams cut down sufficiently to show the underlying Lower Coal Measures.

Of the latter, the uppermost coal bed, or Upper Freeport, alone merits attention. It is however a widely persistent and important bed and is considerably mined where the Pittsburgh coal does not exist.

Township Geology.

In *Marshall Twp.* the Barren Measure shales make up the greater portion of the surface rocks.

The Upper Freeport coal is fully 100′ beneath the surface in the lowest part of the township, the rock section extending up probably to the horizon of the Morgantown S. S.

The Crinoidal limestone, red shales, and the Brush Creek limestone and coal can be seen along branches of the Big Sewickley creek; but on the whole, the exposures in this township are unsatisfactory and largely made up of shale.

Pine township, next east along the Butler county line, shows exposures extending from the Pittsburgh coal down to about 75′ below the Crinoidal limestone, or a section of nearly 400′. The coal is mined by Mr. Emmitt, just east from Pierce's branch of Pine creek at about 1360′ A. T.

The bed is from 9′ to 10′ thick, the lower division being 5′ and furnishing about 4′ of coal.

The Elk Lick coal, 275′ ± below was also sparingly mined by Mr. Emmitt, but was found variable.

The Crinoidal limestone still lower, is recognized at various points, and the Bakerstown coal on Mr. Graham's land on Brush creek, 75′ below the limestone. The greater part of the general surface of the township is occupied by the Morgantown S. S., and accompanying shales, above and below it.

Richland township comes next east of Pine, and marks the source of several streams, notably Deer and Pine creeks. The rock section here extends from about the Morgantown S. S. to within the Mahoning S. S. measures.

Along the Butler line, even higher measures come in above the Morgantown S. S., but not up to the Pittsburgh coal.

Near Bakerstown, the typical coal bed so named has been mined by Mr. Flick. It was reported there as 2′ thick with 11 inches of cannel coal at the bottom; and south of the village, at Mr. Douglass', 2′ 8″ thick, with three thin slate-bands. Of course this bed is only locally developed; but with the Freeport coal 100′ under water level, and the Pittsburgh bed out of the highest hill tops, it becomes relatively important to the people of the region.

West Deer township adjoins Richland going eastward, and in many respects its section is no more satisfactory. The Brady's Bend axis passes through it west of Culmerville, and brings up the Upper Freeport coal on Bull creek and Big Deer, but *not* on Little Deer. The Pittsburgh coal is caught in a high knob along the Indiana township line; and all the remaining portion of the township, with these exceptions, is occupied by the Barren Measure rocks.

At Mr. Brewer's bank on Bull creek, the Freeport coal is over 10′ thick, including shale and dirty coal and 2′ of impure cannel on top.

The lower part of the bed has furnished 3½′ of tolerably pure coal, though rather sulphurous.

Further down this creek, the coal has been mined at various places in coal hill and close by the Fawn Twp. line by Mr. M. Dawson, where it shows the following section:

Upper Freeport,	*Coal,* slaty,		6″	4
	Coal,	3′	0″	
	Parting,		½″	
	Coal,	0′	5″	

This is about the normal thickness of the bed.

On Little Deer creek, erosion has not yet advanced far enough to expose this coal. Below Culmerville the rocks dip south-east, away from the anticlinal and occasionally expose Barren Measures. The Crinoidal limestone is occasionally seen; but the hillsides are mainly composed of brown and buff shales about two hundred feet thick.

On Big Deer, the anticlinal just elevates the Upper Freeport coal to creek level ¼ mile above the mouth of Dawson branch; but it soon disappears again on a north-west dip.

Mr. J. Martin mines the coal ½ mile below this by means of a slope. The coal is from 6′ to 9′ thick but cannot be relied upon for more than 3½′ of good coal. The principal variation occurs in the top coal thickening from 1′ to 4′. The Barren exposures are unimportant.

Fawn township lies next east along the Butler county line.

Harrison, *East Deer* and *Springdale* can be advantageously treated of at the same time, for together they fill out the irregular boundary along the Allegheny river, and the geology of one rather dovetails into another.

Various streams entering the river have cut down through the Barren Measures into the Lower Coal Measures and exposed the strata of both series.

Along the Butler county line, the hills are covered with the Barren Measures up to 100′+ above the Crinoidal limestone. The Upper Mahoning (Buffalo) sandstone is cut bare at Burk's mill on Little Bull creek, where its base is 100′ above the stream. Two miles below, at the mouth of Negley's run, the Upper Freeport coal is first exposed, 3′ 8″ thick at Burtner's.

The Brush creek coal bed is found about 60′ higher at this point. Down stream, the Freeport coal is again concealed until the Methodist camp meeting ground is reached, and is again opened by Mr. Pugh near creek level, with the

Buffalo S. S. on the hill top. The coal here shows the following section:

Upper Freeport Coal,	Slaty *coal,*		5″	3′ 6″
	Coal, ...	2′	9″	
	Slate, ...		½″	
	Coal, ...		3″	

The Lower Mahoning S. S. is well seen just above the coal. The limestone beneath the Upper Freeport coal is likewise somewhat quarried here, occurring in three layers of 1½′ to 2′ thick separated by thin shale.

At the mouth of Little Bull creek the Upper Freeport coal is 130′ above the stream, at Mr. Leslie's bank; and at Mr. Hare's bank on the right bank of Big Bull creek, it occurs in excellent shape,—clean, lustrous coal, with the following section:

	Sandy shales, ...			8′
Upper Freeport Coal,	Slaty *coal,*	1′		4′ 4″
	Coal, good, ...	3′		
	Slate, ...	0′	1″	
	Coal, ...	0′	3″	

The bottom 3″ is pyritous and not mined.

The coal is dipping rapidly south-east from here down Bull creek, and at Tarentum is only 80′ above the river.

Following up Big Bull creek, the Upper Freeport coal outcrops continuously to above McDowell's run, where it has been opened by Mr. McDowell 4′ 2″ thick with partings, and with the Buffalo sandstone crowning the hill top. Various other openings occur between these two points; but the coal section is fairly similar.

A local but sharp anticlinal crosses the creek just *below* the mouth of McDowell's run, reversing the dip of the measures for about ¾ miles, when the strata rise towards the north-west again in the direction of Millerstown, about as fast as the stream. On the Lardintown branch of Bull creek, the Upper Freeport coal does not appear until opened at McGinness' bank, just close to the Butler county line.

At Millerstown, the Brush creek coal shows near the sandstone along the bank above the mill. It is a mixture of slate and impure coal, and is about 40′ above creek level. Still ascending the creek, the Upper Freeport coal rises to daylight ¾ miles above the village, at Mr. Thos. White's, where it was once mined, passing thence into West Deer.

In *East Deer* and *Springdale* townships, no large streams rise nor flow ; but numerous short ones, with rapid fall, rise along the Indiana line and flow to the river. For this reason the exposures of the Lower Coal Measures are entirely confined to the immediate vicinity of the river.

On Day's run, the Upper Freeport coal ascends ½ a mile above the mouth of Robertson branch, and the sandstone below it here occurs in massive conglomeritic layers. It has been mined just below the month of Robertson by Bailie Bros., and shows the following section :

Upper Freeport Coal,	1. Cannel *coal*, . . .	2′		9′ 7½″
	2. Bituminous *coal*, .	2′	9″	
	3. Slate and bony coal,		8″	
	4. *Coal*, ...	2′	10″	
	5. Parting, . . .		¼″	
	6. *Coal*, ...		4″	
	7. Parting, . . .		¼″	
	8. *Coal*, ...	1′	0″	

The top portion of the bed is duplicated apparently, though a nearly identical section was obtained at Hite's bank, a little further down stream, where Nos. 2 and 4 are each 3′ thick and the bottom coal, No. 8, 10″ thick.

Considerable coal was formerly shipped from here to the industrial establishments along the Allegheny river.

The unusual development of the bed indicated in the above section commences about ½ mile above Hitestown. Above that it is only 4′ thick.

The rest of these two townships south from Hite's run, is occupied by Barren Measure rocks, which are everywhere nearly the same, and present nothing of interest.

Near the head of Hite's run, what is supposed to be the Elk Lick coal, occurs at 360′ above the Upper Freeport, on land of Mr. Simon, formerly stripped and drifted upon to some extent.

Indiana, *Harmar* and *O'Hara townships* form together a nearly rectangular block of territory except where cut off on the north-west by Hampton and on the southeast by the river. They lie south of West Deer, and along the river front comprise all the territory between Sharpsburg and Lincoln's station on the West Penn R. R.

This area is largely drained by Big and Little Deer creeks, which uniting close to the north line of Harmar, flow south to the Allegheny river at Harmarville.

The Brady's Bend axis lies to the north-west of Indiana Twp., and in Hampton, so that no member of the Lower Coal Series is exposed here.

The Upper Coal Series however are still preserved, and some small areas of the *Pittsburgh coal bed* can still be seen in the northeast corner of Indiana, west from Little Deer creek.

At Wm. Marshall's drift, the following section shows:

Pittsburgh coal,	Roof Div.,	Slaty coal,	2′	0′	8′
		Shale,		3″	
		Coal,		5″	
		Shale,		3″	
	Lower Div.,	Breast coal,	3′	4″	
		Slate,		¼″	
		Bearing in,		5″	
		Slate,		¼″	
		Brick and bottom coal,	1′	3″	

The thickness of the main clay parting, only 3″, is rather noticeable. The bottom coal is as usual, impure.

Remnants of the Pittsburgh S. S. are still found on the summit of the hill, 40′ above the coal.

There is about 10 acres of the Pittsburgh bed here.

Immediately south, there is a larger 20 acre patch, on J. Marshall's land. The coal section is about the same. A third 10 acre patch is caught in a knob a little further south, formerly operated by Mr. Johnston.

The roof coal here is quite impure and 3′ 7″ thick. Breast coal 3′ 2″; Bearing-in 7″, and Lower Bottom and Brick 1′ 5″.

The last knob of the Pittsburgh coal is caught in a summit on Mr. Lefever's land, about ¾ miles south from last. All the coal described has been dipping south-east.

Passing down Little Deer creek, the Crinoidal limestone is reached at 300′ below the Pittsburgh bed, the following section showing at Conahy's knob, just missing the Pittsburgh coal:

1. Concealed from top of knob,			40′	0′
2. *Limestone*, (Pittsburgh,)			2′	
3. Concealed,			230′	
4. Shaly sandstone,			6′	
5. *Coal*, slaty, (Elk Lick,)			1′	6″
6. Concealed,			30	
7. *Limestone*, Crinoidal,	1. Limestone,	1′ 0″	2′	4″
	2. Shale,	0′ 4″		
	3. Sandstone,	1′ 0″		
8. Concealed,			120′	
9. *Pine creek limestone*, in bed of creek,			1′	6″

Still lower measures are exposed further down the creek, a limestone 1½′ thick (Brush creek limestone ?), being visible at the mouth of Little Deer, 180′ below the Crinoidal.

It is very fossiliferous and is accompanied by a small coal beneath it, presumably Brush creek coal, under which comes massive sandstone 18′ thick to the stream.

The *Pittsburgh coal* is again caught on a high summit ¾ miles north-west from the mouth of Big Deer, and on Mr. Campbell's land. Another small patch shows on high ground west of the creek and on the north side of Guy's run.

Passing up Deer creek into Indiana, the Crinoidal limestone is seen on Cretz's land, 200′ above the creek.

Below Yonker's mill, the Brush creek limestone is seen in the bank of Blue run, capped with reddish shales.

The Pine creek limestone is seen in a ravine below Dorseyville, and a mile west of the village coal was once mined on Weber's land, probably Bakerstown, 2½′ to 3′ thick.

The rocks of O'Hara twp. belong entirely to the Barren Measure group, none of the streams being sufficiently large to cut down to the Lower Coal Measures.

Hampton and *Shaler townships* lie immediately west of the territory just described, and owing to the presence of Pine creek, which flows tortuously through them both, from north to south, the Lower Productive Measures and coals are exposed.

The presence of the Brady's Bend anticlinal, passing through Hampton and crossing Pine creek, at the big bend below School House No. 4, further assists this display. The channel of Pine creek is, in many places, a mere gorge, cut down through the massive sandstones at the base of the Barren Measures.

It enters the river just below Sharpsburg, where the Upper Freeport coal bed is from 80 to 100 feet below the level of the Allegheny.

The Brush creek limestone shows 1½′ to 2′ thick at the roadside near the Ætna Iron Works. Ascending the stream the rocks are rising rapidly towards the anticlinal.

Opposite the mouth of Little Pine, the Mahoning S. S. is found in perpendicular cliffs along the main stream.

At Glenshaw, 3 miles above Sharpsburg, the *Upper Freeport* is brought above water level, and at Shaw's shows :

Upper Freeport coal,	*Coal,*	3′		7′ 6½″
	Coal and slate,	1′		
	Coal,	3′		
	Parting,	0′	½″	
	Coal,	0′	6″	

The coal here is similar to Deer creek and Hitestown. The upper bench is impure; the lower excellent, with but a small percentage of sulphur and ash.

The Crinoidal limestone is seen on top of the hill, 320′ above the Upper Freeport coal.

Miller's opening is one mile above Shaw's Mill. The entire bed is here 4′ 8″ thick, and furnishes about 3½′ of good coal. This thinning of the coal in one mile, continues going up the stream for some distance, where the horizon of the bed is identified, but almost without workable coal.

Above the Nine Mile house, on the Butler plank road, the coal thickens to about 3′ at Mr. Hieber's bank, 40′ above creek.

Further north, in Hampton Twp., the bed thins out almost entirely. Near the mouth of Gourdhead run, its underlying limestone is seen with nothing but a black streak of shale above it to represent the coal.

The anticlinal crosses Gourdhead run at Mrs. Meyers', where the *Lower Freeport* coal is just brought up to creek level, 2′ thick, and 35′ below the Upper Freeport. The hill top here is crowned with the Buffalo or Upper Mahoning sandstone, so that most of the Barren Measures have been eroded from off the crest of the axis.

The Brush creek limestone and coal are noticed here on Mr. Herron's land, and 28′ below the latter a double bed of fire clay, consisting of an upper plastic portion and a lower non-plastic.

In the high ground between Gourdhead run and Pine creek the Barren Measures, for 50′ above the Crinoidal limestone, are exposed, the limestone being somewhat earthy and impure, but still retaining its greenish cast and its Crinoidal fragments and fossils.

The *Pine creek limestone*, so named from its occurrence here, is 2′ thick, a dark arenaceous stone, fossiliferous and lying immediately on top of the Buffalo or Upper Mahoning S. S. Passing to the west side of the anticlinal, the rocks are found dipping rapidly north-west.

Thus at the mouth of Crouse's run, the *Brush creek limestone* is only 40′ above Pine creek; at Montours run, the *Pine creek* limestone is only 15′ above water level.

The Upper Freeport coal has passed under water level near Bryant Sta. on the Pittsburgh and Western R. R., within a mile from the anticlinal.

Girtie's run flows through the south-eastern portion of Shaler township.

The *Crinoidal* limestone is about 110′ *above* the Allegheny at its mouth, and the Upper Freeport coal 180′–190′ *below* the bed of the river.

About 2 miles from the river, a small area of the Pittsburgh coal catches in a high hill rising 450′ above Girtie's run and was once mined on Irwin's land. There are only a few acres.

McCandless township lies immediately west of Hampton, which it resembles in size and shape; south of Pine and north of Ross, with Franklin on its western side.

Pine creek flows nearly west a little north of its centre, while Girtie and Lowrie runs head up in its southern part.

This township lies in the trough immediately west of the Brady's Bend axis, a synclinal possibly coincident with the Mansfield basin south of the Ohio river.

The Pine creek limestone is the lowest rock exposed in the township, visible in the bed of Pine creek, just where it leaves the township. The *Pittsburgh coal* is caught in an isolated knob at the western line of the township, so that the vertical column of rocks exposed approximates 425′. The Upper Freeport coal is nowhere less than 180′ below water level.

The Pine creek limestone is seen just above water level a short distance above the mouth of Montour's run, dipping N. W.

Below Montour's run is the Buffalo (Upper Mahoning) S. S., which is so largely exposed to the south-east in Hampton.

The Elk Lick and Bakerstown coals were both sparingly mined near the old Buckeye hotel, though both were impure.

The *Pittsburgh coal*, with a light covering of Pittsburgh S. S., was formerly mined by Messrs. Sarver and Neeley at about 1325′± A. T. The roof coal was 4′ thick, with shale layers; the Main clay 1′ 2″; Breast coal, 3′ 4″; Bearing in 5″, and Bottom 1′ 9″. It was impure, owing to light cover, and mostly removed. The Crinoidal limestone occurs 290′ below it and 40′ above Pine creek. Below Pierce's mill, on Pierce Branch, the same rock is 80′ above the creek and underlaid by thick red clay bands.

Ross township lies immediately south of McCandless and north of Allegheny City, and west of Shaler.

It contains much high land and many small and unimportant streams. Girtie's run cuts across it from north-west to south-east and exposes fairly satisfactory sections of the Barren Measures.

The *Pittsburgh coal* is found in several high knobs between Spring Garden and Butcher's creeks, and at William's bank shows the following section:

Roof Div.,	*Coal*, slaty,	2′ 4″	4′	9′ 10″
	Shale,	6″		
	Coal,	1′ 2″		
	Main clay shale,		8″	
Low. Div.,	Breast *coal*,	3′ 6″	5′ 2″	
	Bearing in *coal*, with usual slates,	4″		
	Bottom *coal*,	1′ 4′		

It will be seen how closely this section compares with the Monongahela river coal near Pittsburgh.

Just north of this there is another small patch owned by Miss Neely, and Mr. Layng. At the head of Spring Garden run there are two outlying spurs of this bed on Mr. Ramsey's land, each of about three acres.

Two more show at the head of Wood's run, on Mr. Goff's land, and ½ mile still further north, and east of the Perrysville plank road, there is another acre of coal on Mrs. Rodenbaugh's land. These last three areas are supposed to mark the position of the Brady's Bend axis. They are about 600′ above the Ohio river or 1,300 feet above tide.

Reserve township and the *City of Allegheny* occupy all the territory south of Ross to the junction of the two great rivers. Spring Garden and Butcher runs flow through Reserve with a rapid fall, and empty into the Allegheny above the city. Woods run passes through the city with a south-west course; crosses the Fort Wayne railroad at Woods Run station, and enters the Ohio opposite the north-west end of Brunot's Island.

The Crinoidal limestone, with its little coal 1′ thick just beneath it, outcrops along the river front, slightly above railroad level. An upper black decomposed limestone crops here about 35′–40′ higher, seen in the cuttings of the West Penn R. R., between Girtie's and Butcher runs, *overlaid* with Elk Lick coal 2′ thick. Owing to the north-west rise in all the measures towards the Brady's Bend anticlinal, these limestones are exposed almost continuously along Spring Garden and Butcher runs. The anticlinal, after crossing Girtie's run in Ross, curves slightly to the south, passing west and outside of the limits of Reserve Twp., but coursing through the north-west portion of Allegheny City to the river at Woods run. Its effect at the river has caused a vertical hoist in the measures of about 160 feet, raising the Crinoidal limestone there 200′ above the river as against 40′ at the intersection of the rivers. The measures rise north-west towards it about 100′ per mile.

The *Pittsburgh coal*, still patchy and isolated, is caught in the summits in the northern part of Reserve township. It is everywhere about 300′ above the Crinoidal limestone. The top of the Morgantown sandstone, 50′ thick, lies about 50′ below the coal. It is largely quarried for building purposes back of Allegheny city, and is a fine gray sandstone.

At Woods run, on the Ohio, along the line of anticlinal, the Barren Measures are exposed down to and below the Brush creek coal. The most noticeable feature of the section is the Buffalo (Upper Mahoning) sandstone, which is here 50′ thick, and crops all along the railroad from Woods run to Haysville. It is not to be confounded with the Morgantown sandstone, which lies more than 200 feet higher in the measures and 100 feet *above* the Crinoidal limestone.

The remaining portion of the county north of the Ohio river, is comprised in Franklin, Sewickley, Ohio, Left and Aleppo and Kilbuck townships.

Franklin township is an irregular triangle, lying south of Marshall and pointing on the Beaver Co. line, where it is cut off by Sewickley creek. It is mostly drained into the Ohio. The *Pittsburgh coal* is retained in three isolated knobs, two along the McCandless line and one near the junction of Sewickley and Ohio townships. The rest of the area is occupied by Barren Measures, with the Upper Freeport coal at least 100 feet under water level.

The Pittsburgh coal at Mr. Schuring's, along the south line of the township, is found in a high knob, 20′ beneath summit. *This is the most western remnant of this bed in the county.* There is only about an acre of it left, nearly all of which has been mined out.

Another five acre knob of this coal has been considerably mined in the past on Mr. Wright's land towards the south-east corner of the township.

The following section shows there:—

Concealed, hill top,				30′
Sandy shales,				3′
Roof Division,	Coal,	2′ 6″	6′ 0″	12′ ±
	Shale,	1′ 6″		
	Coal,	2′ 6″		
Main clay parting,			1′ 2″	
Lower Division,	Coal,	2′ 9″	4′ 9¾″	
	Slate,	½″		
	Coal,	4″		
	Slate,	¼″		
	Coal,	1′ 8″		

The third area of the Pittsburgh coal, about 4 acres, partly in Franklin and partly in McCandless, is mined on Mr. Vandeverd's land. The mining coal is about 5′ thick.

The *Elk Lick coal* has been quite extensively mined on Mr. Aiken's land, on Duff's run in the northwest part of the township, where, in lieu of something better in the way of coal, a large country trade was done with the product of this bed. The coal is 2′ 8″ thick, the top 8″ being an impure cannel. The bottom coal is bright and quite pure.

The bed lies 25′ above the Crinoidal limestone, here a mass of fossils.

Ohio township lies immediately south of Franklin and shows nearly the same section of rocks, though no Pittsburgh coal is left within its limits.

The Crinoidal limestone is again a well recognized rock through much of this township. It is seen 110′ above the left branch of Lowrie's creek at Mr. Thompson's place, 2′ thick and with a greenish cast. Also on Killbuck run near the school house, 45′ above the creek.

The limestone and red clays 90′ beneath the Pittsburgh coal, are exposed in the hills between these two streams; but there is only about 50′ of cover to the hill top, and consequently too little to catch the horizon of the coal. The Killbuck cuts into the Buffalo S. S. a short distance below Duff's mills, where it is massive and forms cliffs for some distance down stream.

Sewickley township joins Ohio on the west side and lies next to the Beaver Co. line, here marked by Sewickley creek. Little Sewickley creek flows through its eastern portion; but does not cut down into the Lower Coal Measures.

Hence no exposures of the Upper Freeport coal occur; nor are the summits high enough to catch the Pittsburgh bed.

The Buffalo S. S. crops on Little Sewickley near the Left township line, as on Killbuck creek, and forms precipitous walls in ascending the creek towards Franklin.

The balance of the township is occupïed by the Barren Measure rocks solely; they are without special significance here and the township calls for no economical description.

Left, Aleppo and Killbuck townships occupy the north bank of the Ohio river, from the mouth of Big Sewickley creek to West Bellevue at the Davis Island dam.

At the Beaver line the Mahoning S. S. is seen as a massive outcrop at the mouth of Big Sewickley and is quarried in Left Twp. just above the Beaver road crossing.

The Mahoning S. S. keeps above water level going up the creek for some distance, owing to the rise to the northwest.

The Crinoidal limestone is met with in the hill tops, full of fossils, and generally in loose blocks.

The horizon of the Upper Freeport coal should be found at about water level in the Ohio at the mouth of Big Sewickley; but it is extremely doubtful if the bed maintains a commercial thickness here.

Three terraces are well marked along the Ohio here, the second one, 80′ above the river, forming the site for the village of Sewickley, in the southeast corner of Left Twp.

The Mahoning S. S. is again met with on Little Sewickley creek, at the Beaver road crossing, and has been extensively quarried. It is a coarse-grained, grayish-white rock; but resists the weather well and makes an admirable building stone.

Two miles from the river, the Brush creek limestone and coal comes down nearly to creek level, and the coal has been stripped on Mr. McKane's land. It is only1′ 6″ thick.

One mile above the mouth of Killbuck run, in Aleppo

Twp., the Brush creek limestone is just above water level, which conceals the coal. In the hillside here, the Buffalo S. S. shows 75′ in a perpendicular cliff; the Pine creek limestone next on top of the sandstone, and 80′ above the stream; somewhat brecciated and fossiliferous; the Crinoidal limestone 115′ higher and 2′ thick, and finally the Morgantown S. S. in a massive cliff, on the hill top, whose fragments cover the sides with a coarse, compact sandstone.

The measures are quite flat here, and west of Killbuck rise to the north-west, soon throwing the Morgantown S. S. out of the hilltops. Nearly the same measures are exposed further east on Lowrie's and Spruce runs, the Buffalo sandstone being quite prominent.

2. *Eastern Allegheny.*

This district, as has been already stated, comprises all that portion of the county lying between the Allegheny and Monongahela rivers, with Pittsburgh at its western extremity. Besides the city, it contains 10 townships arranged somewhat as follows:

1. Plum,
2. Penn,
City of Pittsburgh.
5. Patton,
3. Sterrett, 4. Wilkins,
6. North Versailles,
7. South Versailles,
8. Lincoln,
9. Elizabeth,
10. Forward.

The city limits of Pittsburgh now extend considerably south of the Ohio river, and incorporate many of the boroughs south of the Birmingham-Temperanceville Heights. All that portion south of the river is so irregular in its outline that I have deemed it best to describe it *geologically* in connection with Lower St. Clair and Union townships, which in the near future will probably form a corporate part of the great city. The year of foundation of the city—then called *Fort Pitt*—is generally fixed as 1760, and since the mining of coal on the Monongahela was commenced in the same year, the date is a useful one to remember.

Only five years previously had Braddock met his disastrous defeat a little further up the river.

In 1800 the first foundry was built in Pittsburgh; in 1812 the first rolling mill.

The population of the city 100 years ago (1786), three years after the sale of the manor of Pittsburgh by the Penns, and the establishment of city lines, was all accommodated in "thirty-six log houses, one stone and one frame house, and five small stores," according to history's chronicle.

The earliest census, taken in 1796, returned the population as 1300. In 1800 the number had increased to 1565, and in the last census year, 1880, to 156,381, Allegheny City at the same time returning 78,681, and the whole county 355,759. Rapid and great as has been the increase in population, Pittsburgh's industrial progress in the same time has been almost marvelous, especially in the coal, iron, steel and glass industries. And now that she has received a further impetus from the rapid and nearly universal utilization of Natural Gas, so applicable to most of the largest industries, she has become in 1886 the pride of the State as a manufacturing center and the envy of her competitors in neighboring States.

To do justice to her manifold interests would be as hopeless a task in this report as it is manifestly out of place, dealing as it does distinctly with the Pittsburgh Coal Region. With its magnificent rivers and railway system, its supremacy is not to be wondered at, and no money spent on either seems to have turned out a bad investment to the capitalist.

City of Pittsburgh, north of the Ohio.

The city comprises within its limits what were formerly Pitt, Peebles and Collins townships on the old State map. By far the greater portion of this area is occupied by the

Barren Measure series, the Pittsburgh coal bed being confined to the highest summits, in isolated patches over 1000 feet above tide, except in that portion of the city south of the Monongahela and Ohio rivers, where this coal bed has a mining area of considerable extent.

The *Nineveh synclinal*, whose trough is really a subordinate anticlinal, reaches the Monongahela from the south in the neighborhood of Walton's Six Mile ferry works, to the east of the city limits, in Baldwin township. The basin cannot be detected north of the river.

The *Washington anticlinal* enters from Scott township on the south closely following the Washington pike, and lifting the Pittsburgh bed by reason of its north-east rise, to an elevation of about 1030′ A. T. along the river bluff. Its exact location cannot be well made out, for its strength as a distinct axis is visibly decreasing as the river is approached, with the effect of creating a broad plateau of the Upper Productive and Barren Measures, deeply furrowed however by Saw Mill run and its numerous branches.

As a consequence of this the Pittsburgh coal from Temperanceville on the west to the eastern limits of the city beyond the Jones and Laughlin mines nowhere varies 20 feet in elevation along the river bluff. This axis is likewise indistinct north of the river, unless, as is probable, it bends or laps past the Brady's Bend axis.

In that portion of the city contained between the Allegheny and Monongahela rivers there still remain a few patches of the Pittsburgh coal, with but little covering of the Upper Productive Measures. The coal has been largely exhausted.

Thus in Squirrel Hill, in the south-east portion of the city and in line with the continuation of the Nineveh synclinal, there is quite a prominent area, one and a half miles long, lying between Four Mile run and the big bow in the river at Glenwood.

Mr. Brown's coal works — now abandoned — formerly mined from the area and this old incline and pit can still be seen facing the river at Brown's Sta. on the B. & O. R. R. The coal at this pit is 1040′ A. T. and about 330′ above the river. Its thickness here could not be measured. The coal is nearly cut out by the Squirrel Hill road, but northwards swells out into a heart-shaped area, extending to the ravine of Four Mile run.

East of Brown's chapel and the Salt Works road, there is another small area of coal, opened on its northwest outcrop at *Cannon's bank* 1064′ A. T., with possibly 50 feet of cover.

The coal mined here is said to drain N. W. and S. W., or away from the Pin Hook axis to the east.

On either side of Forward ave. the Pittsburgh coal is found in small blocks. *Fleming's* country pit is opened on the south side at 1097′ A. T. and the *English* pit on the *north* side of the hill north of Forward ave. at 1102′. At both places the coal drains westward. The lower division coal at these pits varies from 5′ 4″ to about 6′, of which the lower bottom 1′ to 1′ 6″ thick is not mined.

The breast coal is a little over 3′ thick and brick coal 10″ to 1′; so that the mining coal may be gauged as 4 thick.′

The map will show several other small areas of this bed, two such occurring along Forbes street, and opened on south side at the *Irwin* pit, at 1108′ A. T., close to Shady Lane.

This is hardly 2 miles air-line north from Brown's pit, the difference in coal level being (1108′–1040′) 68′ or 34′ per mile.

North-west from East Liberty and between Penn ave. and Morning Side road, the coal in the Winebiddle Est. is about 1080′ A. T. There are only about three acres of coal left here. Breast coal 3′ 6″; bearing-in coal 4″; brick and portion of lower bottom 18.″ Opened by a face entry.

The Pittsburgh coal also outcrops along the Penn Twp. line, and extends slightly into the city limits. It will be mentioned in the description of Penn Twp.

Herron hill, north-west from Fifth ave., still contains some little coal; but a glance at the map will show clearly that there is but little merchantable coal left in this part of the city.

The coal has scarcely more than sufficient cover to make it good ; but in the past these small patches have contributed largely to the city demands, and as they drained themselves and contained coal of good quality and great regularity it is fairly possible that they would still be very active if it were not for the growing use of natural gas.

The Barren Measure rocks are the surface rocks through the greater part of the city, and are exposed down to 350′–400′ below the Pittsburgh coal. With the exception of the Crinoidal limestone, none of the "key rocks" of that system are very well developed. The Morgantown S. S. is thin and flaggy, and often deteriorates into shale. The limestone however was identified at several places along the river bluff, and extends as a characteristic and persistent rock far up the Monongahela towards Port Perry.

The exposures along the Allegheny River within the city, are in the main unsatisfactory.

Penn township lies east of Pittsburgh, extending along the Allegheny river to Verona. Plum creek is its north boundary line and Thompson's run its eastern line, while Sterrett and Wilkins townships lie south of it.

The river topography is exceedingly bold and beautiful, and the Barren Measures which make up the surface rocks here, are deeply grooved by innumerable small streams descending from the highlands to the southeast. The drainage of the township is almost equally divided between the Allegheny and Monongahela rivers, Sandy creek and Plum creek flowing into the former and Thompson's creek to the Monongahela. The latter stream has its source largely in this township.

The *Pin Hook anticlinal* cannot be very distinctly located in its course through this township, owing to the great erosion and limited amount of coal left along its course. But a glance at the coal levels on the map will suffice to show that it must lie quite close to the Allegheny river, and as already stated can be *approximately* located near the headwaters of Nine Mile run. Considerable time was spent in this township in the endeavor to locate its position definitely. The elevations recorded are not entirely reliable owing to absence of facilities for the frequent comparison of barometric observations with established railroad levels. But it was sufficiently determined that the dip of the *Pittsburgh coal bed* and accompanying measures is throughout the township, *towards the southeast*, with the possible exception of the area along the Frankstown road, in the south-west corner, where the variation is very slight and the coal apparently quite level, while of course conforming to the north-east rise, parallel to the line of axis, prevalent elsewhere in the township.

Thompson's run approximately marks the position of one portion of the Waynesburg synclinal trough.

The *Upper Productive Coal Measures* occupy a considerable but exceedingly irregular area in this township.

They are almost entirely eroded from the northern portion of the county and wherever preserved there is rarely 100′ of cover to the Pittsburgh coal at their base.

Streams have cut into the outcrop of the Pittsburgh coal everywhere, so that it is only available along the crests of some of the high and narrow ridges.

It was formerly quite extensively mined for shipment by the Allegheny river and railroad. At present the New York and Cleveland Gas Coal Co. are the only operators, and when visited, even their extensive plant was idle.

Messrs. Stewart, Dickson & Co. formerly mined quite close to the river along the city line. The bed at the abandoned *Coleman bank* is about 1150′ A. T. The outcrop extends thence around a high hill, across the Frankstown road and around the forks of Nine Mile run. Though thus isolated, the coal area is quite large.

A large county trade has been done and is still being carried on to satisfy local wants at East Liberty and Wilkinsburg, at Masons, Elks, Lytles and other pits along the Frankstown road. The location of these pits is shown on the map. They all approximate 1150′ A. T.

In all the roof coal is from 3′ to 3½′ thick; the main clay parting 9″ to 1′ and the lower division 5′ 4″ to 5′ 11″. The mining coal is about 3′ 2″ of breast, and about 4″ of brick which, with the bearing-in, makes in all 3′ 10″. The lower bottom is dirty; and the whole bed quite irregular.

These pits are all on the old Kane property.

South of the public road, there is a considerable country opening on Lytles place at 1148′ A. T., and Eders has opened on the south side of the hill at 1133′.

West of Nine Mile run and close to the city line, the coal was formerly worked at Billingstein and McKenzie's pit at 1130′ A. T. In all of these places the section is quite similar, and the general character of the coal very good.

Lying high on the hills, with small areas and an open outcrop, the question of drainage is very simple.

One of the entries of the N. Y. and C. Gas Coal Co. enters this hill on the east at 1128′ A. T., crossing the Sandy Creek road ravine by a trestle and outside track.

This company is a large holder of coal land in this and Plum township, though inactive during 1885-'86.

The *Sandy Creek mines* are reached by a broad guage track, leaving the Allegheny Valley road at Sandy Creek Sta., and following the creek for about three miles to the village of Sandy Creek where the openings are located.

These mines have furnished a high grade of gas coal to the market and the workings are quite extensive.

Owing to the excessive irregularity of the outcrop here the working entries are laid out so as to reach the greatest area of available coal, while keeping as far as possible to the cleavage planes of the coal.

The dip is south-east throughout the mines, and for reasons already stated, no trouble is experienced in draining them.

There are three working pits in the front hill, back of the village. The coal elevation approximates 1080′ A. T. at all of them, and is about 270 feet above the company's railroad track, which is reached by inclined planes from the pit mouths.

A general section of the mining coal hereabouts shows:

Sandy Creek, N. Y. & C. G. Coal Co., .	Main clay parting, . . .	1′	6′ 2″ to 5′ 4
	Breast coal, ...	3′	
	Bearing-in coal, ...	8′–6″	
	Brick coal, ...	1′ to 10″	
	Lower bottom, ...	1′ 6″ to 1′	

The lower bottom is, as usual, rather impure, and some little pyrites occasionally creep into the brick coal bench. Most of the coal has been removed from the front hill, several tunnels being driven out to daylight on to branches of Thompson's run and extended through the back hills.

In Mine No. 2 tunnel the coal falls about 18′ from the front pit mouth to the water pit south of the Hepburn church (1061).

For the year ending Oct. 31, 1884, these mines were returned as employing 250 persons, with an output of 138,499 tons. In 1885 their output was 67,994 tons.

From the Sandy Creek mines, the outcrop of the Pittsburgh coal bed extends north-east, crossing the Sandy creek and Pucketa road just below the forks to Verona. Here the coal is caught in a potato-shaped knob marking the north-western limit of the crop in this township.

M. Graver & Co.'s mine enters the western edge of this crop at about 1135′ A. T., their coal-road extending by a series of trestles to Armstrong Sta. on the A. V. R. R. (see map). There is scarcely any cover to the coal in the first knob; but crossing the Sandy creek road, their track enters the long narrow ridge at 1131′ A. T. Entering on a butt, the main entry is soon turned to a face and bears south-west, carrying the mine drainage with it to daylight in a small ravine below the Mt. Hope Baptist church.

They bridge this, and after passing through a second outlier, span the next ravine west of Mr. Latham's house. On the east side of this narrow coal ridge, the coal shows at Statler's pit at 1113′ A. T.

A swamp is reported to have been met with just after entering the first hill; but these swamps in isolated outcrops are of not much importance, and, as a rule, are very shallow and narrow.

Graver & Co.'s mines were also idle, and are returned Oct. 31, 1884, as furnishing an output of 57,835 tons for the year. In 1885 the output decreased to 55,944 tons.

From Graver & Co.'s works, the outcrop of the coal swings almost due east, and just north of the Plum creek road. It is opened at *Stewart's* and *Hershey's* pits at about 1130′ A. T., the former by a face entry dipping strongly south-west. The miners also report a small swamp here west of this entry which causes a temporary reversal of the dip to the north-west. The outcrop keeps well up in the hills and on a nearly east course to the

Plum Creek Mine No. 1, (N. Y. & C. Gas Coal Co.) "Clarksville Mine," opened at the head of a small branch of Plum creek at 1086′ A. T. The coal is lowered on an incline to the Plum Creek railroad, a branch about 5 miles long, extending from Verona on the A. V. R. R. into the company's upper mines in Plum township. These mines were also idle, so that no detailed information could be gathered. The assistant superintendent, Mr. H. C. Kier, stated that the main tunnel at the No. 1 mine is directly on the face, about S. 23° W., and is 900 yards long. It is driven to daylight on a branch of Thompson's run north of the Washington school house, where the coal is 1066′ A. T. This fall, if constant, denotes a *south-west fall rise in the measures* in this part of the district, parallel to the trend of the anticlinals and synclinals, of about *38 feet per mile!*

Butt entries have been driven north-west and south-east into the two handsome areas of coal here. The dip throughout is south-east, though east of the Washington school house the dip is very gentle. Single entry system prevails here as elsewhere north of the Monongahela, with rooms 7 yards long, 4 yards of a pillar and 11 yards between entries.

The coal section is about the same here as at Sandy creek, and will average about 5½′ thick.

The quality of the coal however is said to be quite different, for while the Sandy creek product is essentially a gas coal, the Plum creek coal has a much lower percentage of volatile matter and is a stronger steam coal.

Thompson's run and its branches have created a marked erosion in the bed south of the divide between it and Plum creek.

A small heart-shaped area of the Pittsburgh bed is caught in the hill south-west of the Washington school house, and is opened at *C. Conliff's* country pit at 1050′ A. T.

In the south-east corner of the township, the crop is exceedingly cut up by numerous branches of Thompson's run.

The coal has been opened at Henry Morrow's at 1050′ A. T.; at about 1½ miles south-east at W. E. Johnson's at 1040′ A. T.; and shows on Mellon Bros' land, on the Northern Pike at 1075′ A. T.

These points are all located on the map, and from them the dip of the coal can be readily made out.

The general fall, along the line of greatest dip,. will not exceed 40′ per mile south-east, in this township.

While the coal is patchy and rather expensive now to market, owing to long outside hauls and handling, it is everywhere of good quality and uniform in thickness. Outside of the coal, but little interest is attached to the geology of the rest of the township. Exposures extend in places to 150′ above the coal to a limestone which is burned at several localities. The Barren Measures are exposed to a little below the Crinoidal limestone, which is persistent everywhere.

Plum township is the most northern township of Allegheny Co., east of the Allegheny river. It is separated from Westmoreland Co. by Pucketa creek on the north and also has that county for an eastern boundary. South of it lies Patton and west of it the Allegheny river and Penn Twp.

Plum and Little Plum creeks rise in this township and together with Pucketa creek, drain seven-eighths of the township to the Allegheny river. The south-eastern corner is drained into Turtle creek.

The *Pittsburgh coal* is generally found in small and detached areas, almost too numerous to describe and locate. Their position is partially shown on the map.

In the southern portion of the township there are two quite prominent and extensive areas, on either side of Plum creek so far almost untouched.

The southern belongs, in great part, to the New York and Cleveland Co. whose Mine No. 2 "Centre Mines" below the King school house are all equipped, but have not been operated. (Aug. 21st, 1885.) The coal at their pit mouth is about 1080′ A. T.; the same at *King's* pit a little further west, while in a small patch between Thompson's and Plum creeks, east of the Catholic church, the coal is opened at 1085′ A. T. at Gray's and 1080′ at Miller's. In other words the Waynesburg (Thompson's run) synclinal passes close to Miller's opening, or between it and King's.

The southern outcrop of this patch extends just across the Patton line ; but is entirely cut off from the coal of that township.

The *Murraysville anticlinal* lies wholly east of the township ; but its effect is strongly marked in the deep erosion of the south-east corner and in the north-west dip of the coal as far as New Texas.

The map illustrates better than any description the position and shape of the numerous detached areas of the Pittsburgh coal bed in this township.

A curiously shaped area lies to the south of New Texas, extending in two branches north-west and north-east from the old Plum Creek Presbyterian church.

The outcrop crosses the New Texas road a few hundred yards north of the church at 1125′± A. T., and an opening near by shows the lower division over 6′ thick as follows :

Breast coal, 3′ 6″ ; Bearing-in coal, 3″; Brick, 10″; Lower Bottom, 12″.

South-east from here, opposite Jas. Wood's place, a small outlying area of the bed just touches the road at 1145′ A. T. To the east of this the coal passes into the air over the anticlinal.

North-east of New Texas, there are half a dozen small patches left between small branches of Plum creek, each of which is insignificent in size though containing a coal pit worked for the local supply of the community.

A somewhat larger area is held between branches of Armstrong run east of McMath's school house, and a couple of outlying patches are still left in the bluffs overlooking Pucketa creek to the north.

In the larger area the coal has been mined by Messrs. Armstrong, Logan and McMath, and the following typical section of the bed illustrates the character of the coal in this locality (Rep. KK. 390) :—

Pucketa Creek coal section.

Roof Division,	*Coal*,		5″	4′ 8′
	Clay,		10″	
	Coal,		6″	
	Clay,		5″	
	Coal,		10″	
	Clay,		8″	
	Coal,	1′	0″	
	Main clay parting,	1′		1′ 0′
Lower Division,	Breast *coal*,	3′	2″	5′ 0″
	Bearing-in *coal*,		3″	
	Brick *coal*,		8″	
	Lower bottom *coal*,		11″	

The coal is of very good quality, though quite inaccessible.

Still another area, of some extent, lies north of Armstrong run, overlooking Pucketa creek and extending west to the Rev. Jos. Beatty's house.

No levels were taken on these various patches of coal; but along Pucketa creek the coal approximates 1200′ A. T.

The coal along this creek at Dougherty's mill is 350′ above water level, and exposes the Green Crinoidal limestone at about 60′ above creek level. At the mouth of the creek along the river the Barrens are cut down nearly to the Lower Productive Measures.

The red shales are prominently exposed both here and in the numerous ravines in the south-east corner of the township. The Crinoidal limestone is usually seen wherever its horizon is reached; but the Morgantown and Connellsville sandstones are thin and shaly, and form no conspicuous part in moulding the topography here as they have done elsewhere further south.

Patton township lies immediately south of Plum. Thompson run is its western boundary; Turtle creek its south and east line. In all respects its geology is quite similar to Plum and Penn and to North Huntingdon of Westmoreland county.

The *Pittsburgh coal area* is confined to the western portion of the township, the eastern two thirds being occupied by Barren Measure rocks.

Thompson run practically marks the line of synclinal, and it has ploughed down a deep furrow into the Barren Measures along its immediate bed line.

All the coal in the township dips *towards* it however and *away* from the Murraysville axis just outside the township along the Westmoreland Co. line.

The chief drainage of course is to the *south-west* owing to the north-east rise in the rocks.

The principal area of coal left is that contained between the Northern Pike and Turtle creek, and is largely controlled and mined by the N. Y. and Cleveland Co.

This company have a branch road up the ravine of Thompson's run from Turtle creek sta. on the P. R. R., about 2 miles long.

Oak Hill Mine No. 4 is located on the east side of the creek in Patton Twp., 240′ above the track and at 1035′ A. T. The pit mouth is opened about 7′ below the coal, in the limestone, for better drainage, and the present main tunnel is started a little further north and 12.5 feet higher. It is driven southeast over a mile on the butts, under Sch. House No. 1 and out to daylight near Mrs. Clugston's at 1080′ A. T., which shows the rise of the coal towards the south-east. The front hill here, forming the south-west prong, is almost entirely worked out by numerous short entries, self-draining on butts and faces to the outcrop.

From within the mine some distance, a face entry is turned off north-east, passing out to daylight in the first ravine at 1070′, and in the second ravine, just south of the pike at 1100′ A. T., and reaching nearly to the Northern Pike.

From this main face entry, short butt entries lead out to the crop westward, the longer butt entries lying to the right, though also carried in several instances to the rear crop. Thus the coal below Monroeville touched by these works is 1110′ A. T. South of the main tunnel, a face entry has been driven into the Geo. Johnson and E. Boyd coal, south of school house No. 1 where at the head of the creek the coal outcrops at 1060′ A. T.

In No. 3 Butt entry, north, the following section shows:

Pittsburgh coal, . . Oak Hill Mine No. 4,	Roof *coal* and slate, ...			2′ 2″
	Main slate parting, ...			
	Breast coal,	*Coal,* . . .	2′ 7″	3′ 10″
		Slate, . .	½″ ?	
		Coal, . . .	1′ 3″	
	Bearing-in *coal,*			6″
	Brick *coal,*			9″
	Lower Bottom *coal,*			1′ 9″

Of course the bearing-in coal has the usual thin slate seams, both above and below. The presence of a thin slate in the breast coal is a little unusual; and the whole bed is locally enlarged here over the average run of the mine. The chief advantage of this tract lies in its perfect drainage; its accessibility and the good reputation of its coal. The southern extremity of this coal area is being built into by a company operating at Spring Hill, on the P. R. R. The crop here lies nearly a mile from the railroad.

Oak Hill No. 4 was being sparingly worked in 1885. Up to Oct. 31st of the previous year (1884) the report of the Secretary of Internal Affairs shows 274 persons to have been employed around the mines, producing for that year nearly 180,000 tons. In 1885, this mine produced 171,996 according to the official reports of the mine inspector.

The mine is worked by single entry and mule power, and the coal dropped by a long plane to the screens on the branch railroad.

In the north-west corner of Patton, between forks of Thompson's run, there is quite a body of the Pittsburgh coal; and a long irregular strip extends between branches of Thompson and Turtle creeks from the Plum line nearly to the Northern Pike.

Still another crescent-shaped area lies south of the pike, north-west of Haymaker's school-house.

The *Barren Measures* are well exposed along both of the large creeks, though a somewhat more extended section shows on Turtle creek, owing to the presence of the Murraysville axis.

The Morgantown sandstone is again found to be quite shaly here, especially in the upper portion. The red shale and clay bands of the Barrens are readily distinguished and the Crinoidal limestone likewise. Beneath it the section is largely made up of shales and slates down to 450′± beneath the Pittsburgh coal bed.

Wilkins and Sterrett townships form a nearly rectangular block of territory, south from Penn, east from the city line, with Thompson run for its eastern border, and the Monongahela river on the south.

Wilkinsburg and Braddocks, and the large Edgar Thompson steel works at Bessemer are within its lines, while it is distinguished *geologically* by the presence of the Pin Hook anticlinal and Waynesburg synclinal, the former following Nine Mile run through Sterrett; the latter Turtle creek and Thompson run in Wilkins.

Turtle creek is peculiar, in that it first marks the trough of the synclinal as far as Turtle Creek station and the mouth of Thompson's run; then passes directly across the eastern side of the basin until it strikes the Murraysville anticlinal, which it afterwards closely follows along the Westmoreland Co. line.

The coal levels recorded on the map can leave no reasonable doubt as to the fact that the Pin Hook axis, as located south of the Monongahela, is *not* to be continued in a straight line directly through Wilkins Twp.; that its former location there in 1876 was wrong therefore and that, *north of the river*, it lies entirely *west* of Wilkins and probably along Nine Mile run.

At all events, the coal dips universally to the south-east, throughout all parts of the township, and into the synclinal along Thompson's run.

The several branches of that stream have grooved out long barren areas in the coal field here; but between each pair of barren grooves, there is preserved a long and narrow coal hill, with sufficient cover almost everywhere to insure commercial coal, and of sufficient compactness to warrant extensive developments. Some of the earliest coal operations were started here, and as a natural consequence much of the coal is exhausted.

The *Duquesne* and *Hampton Mines* on the west, and *Oak*

Hill No. 3 on the east have been the largest producers. while several abandoned pits along the P. R. R. marked the scenes of former great activity here.

None of the mines were active when visited. Their only salvation in the present stagnation of the coal business, and in the face of vigorous competition from the river mines, lies in the utilization by coking of the slack and nut coal, formerly such a source of profit by reason of the immense local trade to be supplied with this waste for steam purposes. Natural Gas has supplanted all this, and the only alternative is to coke the slack and fine coal, and ship the lump. This plan was being contemplated during 1886, and has already been adopted elsewhere in the region.

The *Duquesne Works* (N. Y. & C. Gas Coal Co.) are reached by a switch from the main line south of Edgewood Sta., at the head of a branch of Nine Mile run at 1092′ A. T. A former opening on the McKelvey farm, a little further south-west, is at 1097′, and the old *Dickson Mine* (abandoned), east of Swissvale 1112′ A. T.; railroad grade at Swissvale being 922′ A. T.

The Duquesne mines are very extensive, the gangways being led into five hills and over four ravines, to coal lying beneath the Greensburg pike.

The coal at the rear end of the third hill is 11′ lower than the pit mouth (1081′ A. T.) and at the entrance to 4th hill 1075′ A. T. Here the main tunnel turns south-east and comes out of this hill at the point in Mucklerat Hollow at 1065′ A. T., and enters the 5th hill.

The coal extends down this branch to within a mile of Turtle creek, crossing the Brinton Sta.—Wilkensburg road between Bowers and Dunbars; the Braddocks road at *Campbells*, where it is opened at 1057′ A. T. and extends up this branch to opposite the school house. Here it encircles the hill immediately above Hawkins Sta., where an abandoned opening shows 190′ above the track at 1073′ A. T., and soon joins the crop at Dickson's near Swissvale.

A small isolated knoll remains between Braddocks and Bessemer station, and at *Curry's pit* the coal is 1068′ A. T.

Throughout this whole south-western block the coal is quite regular, one 10′ swamp being reported in the Duquesne mines ; the coal is good, rich in gas and low in sulphur and shows an average section as below :—

	Roof coal and slate,	3′	
	Main clay parting,	1	
Lower Division,	Breast coal,	3′	2″
	Bearing-in coal,		4″
	Brick coal,	1′	0″
	Lower Bottom coal,	1′	2″

The *Hampton Coal Co. mines*, about 1 mile north of the Duquesne, were entirely idle, and nothing could be learned of the extent of their workings. The pit mouth is just east of Wilkensburg at 1097′ A. T.; *Sutton's country pit* on the north outcrop of the same hill is at 1100′. The coal all dips south-east stiffly, and crops in the ravine below the Greensburg pike at about 1080′±. There is a good solid cover here, under the Lime Hill school, on the pike, and the coal was no doubt fully as good as that mined elsewhere through the township.

The Greensburg pike is laid along the backbone of the ridge here, the coal crop being well marked on either side of it in the streams below, until crossed by the pike at about half a mile from Turtle creek at the *Chalfant pit* 1020′ A. T., where the breast coal is 40″; bearing-in 4″ and brick coal 10″. On the north side of the pike, near the head of the creek, the coal is opened at *Montgomery's pit* at 1057′ and the coal dips from here southeast to the

Oak Hill No. 3 mine (N. Y. & C. Gas Coal Co.), at 1015′ A. T. This mine faces Thompson run and Oak Hill No. 4. It is high above the stream, and close to the synclinal. The mine is opened on single entry system and the territory held here is pretty well worked out. The workings are extensive and lie mainly in the block of coal shown on the map between two large branches of Thompson run. The coal is somewhat thicker here than at Wilkensburg ; but the variation is slight. The output here to Oct. 31 (one year) was about 25,000 tons.

The section of the Barren Measures reaches but little below the Crinoidal limestone—as seen along the river.

The Morgantown sandstone is well exposed along the P. R. R., and is quarried in several places.

The red measures are persistent; but nothing of interest attaches to this series.

Above the coal there is no prominent rock either. At the Lime Hill school house, on the Greensburg pike, a limestone is gathered from an outcrop 6′-8′ thick and 185′ above the coal, and burned near by. Much of Sterrett township is flat, and shows the position of a good portion of the old river channel extending from the neighborhood of Braddocks to above Lawrenceville on the Allegheny.

North and *South Versailles townships* occupy all that portion of Allegheny lying south of Turtle creek and the Penn'a R. R.; west of the Westmoreland Co. line and with the Monongahela and Youghiogheny rivers for its west and south boundaries. The two townships are about of equal area; but North Versailles contains almost all the Pittsburgh coal, some few remnants being left in isolated spots in the southern township.

The *Waynesburg synclinal* skirts the western side of this district, while the *Murraysville* (Roaring Run) *anticlinal* enters the district from the south just above Long Run Sta. on the B. & O. R. R., cutting S. Versailles nearly in half, and passing through the south-east corner of N. Versailles to the Greensburg pike just west of the M. E. church, and thence north-east to Murraysville in Westmoreland Co.

The map will show the very unequal distribution of the Pittsburgh coal.

Throughout N. Versailles the coal rises to the south-east. In the large, unbroken area of the Pittsburgh coal shown in this township, there are at present only two active operations.

Numerous other openings have been made in the past in this body of coal, and the combined efforts of all have pretty nearly depleted the territory.

Keystone mine (Brown & Co.) is a short distance above Port Perry on the east side of the Monongahela river. The present pit mouth is, by barometer, 225′ above the P. McK. & Y. R. R. track or at about 975′ A. T.

There are two traveling openings in the front hill, the most northern being a little off the face, passing through a swamp and thence to daylight. The other, nearly on butts, is further back in the ravine and enters the coal 15′ higher. This tunnel is about $\frac{3}{4}$ miles long, and under cover, forks into two. One branch ("Engine Tunnel") extends N. E. to daylight at 1025′ A. T.; the other extends S. E. to Ludwicks, coming out on the public road below his house at 1070′ A. T. Both tunnels enter the next hill, the lower one coming out below the school house and meeting there one of the Spring Hill mine entries; all worked out.

The upper tunnel reaches the present workings.

The various coal benches of the lower division in this mine are respectively 45″, 3″, 10″ and 12″ thick, though of course liable to local variation. The coal crops around the heads of the different branches of Crooked run to the southeast, and the Keystone workings cross these ravines by short surface roads or trestles and pierce the successive hills.

One of these tunnels comes out to daylight near the White House store at *Tapley's coal pit*, about $1\frac{1}{4}$ miles from the river front. The coal has risen here about 100 feet, showing the marked rise towards the anticlinal.

At the head of Crooked run $\frac{3}{4}$ miles due east of Tapley's it is opened again at the *Oberholtzer pit* and is 60 feet higher or at 1136 A. T. The outcrop is very narrow at this point; but a prong of the main body swings southward here and encircles the summit between branches of Jacks and Crooked runs.

Returning again, the eastern crop crosses the Greensburg pike just west of the cross roads. It is entirely cut off here from two isolated patches lying still further east.

The first, larger, and more northern of these two, just touches the pike at the Mt. Pleasant school house, and is opened just north, on its western side, at *Rush White's pit* at 1156′ A. T.

A section measured at this opening, gave the following results:

Sandstone,		
Roof division,		4′ 6″
Carbonaceous shale,	6″	
Coal,	6″	
Slate,	1″	
Coal,	1½″	
Slate,	½″	
Coal,	1″	
Clay slate,	7″	
Coal,	3½″	
Slate,	3″	
Coal,	1′ 1″	
Slate,	2″	
Coal,	10″	
Main clay parting,		1′ 0″
Lower Division,		5′ 8″+
Breast *coal,*	3′ 6″	
Bearing-in *coal,*	4″	
Brick *coal,*	1′ 0″	
Lower bottom *coal,*	10″+	

The coal seen here was excellent ; firm and bright.

This coal is again opened at *Michael's pit* on the Greensburg pike at 1186′ A. T., and finally on the eastern outcrop on *Mr. I. Miller's place;* one pit on his lane at 1196′ A. T., and another above his orchard at about the same elevation. Coal was obscure at both places.

Wallace pit, on the north side of the same hill, shows the coal well opened, as at White's, at 1180′ A. T.

The *Spring Hill mine* (Dempster & Boyd), situated about midway between Wilmerding and Wall's Sta., on P. R. R., is an old operation of the Westmoreland Coal Co.

There was a fine tract of coal here between Turtle creek and the Greensburg pike ; but it is now largely mined out. Indeed until the summer of '86 the mine had been practically abandoned, Some little coal was being taken from the mine during August while preparations were being made to run coal from the company's new tract in Patton Twp., north of the Pennsylvania railroad.

Spring Hill check house is about 260′ above the tipple or 1030′ A. T., and this is about coal level on the hill bluff. The pit mouth is reached by a surface road of considerable length laid around the crop line to the south-west. Drainage was thus secured for a considerable portion of the front coal. These works have been extended beyond the Greensburg pike in places, meeting there the rear tunnels of the Keystone mine.

The mine was running about 1700 bushels of coal a day in August, '86; partly red-coal. The drainage channels have been allowed to become stopped up in places so that the mine is unnaturally wet. The breast coal is about 3½′ thick, in addition to which about a foot of the bearing-in and brick coal is won.

The dip of the coal is north-west, draining in that direction into Wilmerding hollow, as well as south-west with the sinking of the measures.

The north-crop is punctured again near the head of a small run entering Turtle creek just below the station. There are two pits here, on either side of ravine which formerly belonged to the abandoned Port Perry mine of Brown & Co.

The coal is here about 990′ A. T., and a large portion of the present Keystone workings are drained out of the eastern one of these two pits. A swamp lies between this crop and the Keystone pit, and advantage was taken of it to drive to daylight on the river and drain this portion of the field. All this front coal has long since been removed, though Mr. Connelly is at present (Aug., '86) removing some pillar coal for country use, near the old Dickson and Stewart incline, above the switch of the P. V. & C. R. R.

Besides those already mentioned, there are two additional small patches of the Pittsburgh coal left in this township; one north-west of the Oakdale school house; the other on the south side of Crooked run, along the joint township line, where the *Foster pit* is opened at about 1125′ A. T. There are only a few acres of coal here, left on a high summit.

In S. Versailles, detached and small areas of coal are left in several places, insignificant in themselves, but of great service in locating approximately the course of the anticlinal through a country otherwise bereft of a key rock in in the wide outspread of the Barren Measures.

Thus a little knob of coal shows in *Power's pit* 1068′ A. T. on a high summit back of McKeesport near the reservoir, still within the borough limits.

Another patch, with but little cover, shows on the east side of the anticlinal on Mt. Blanc where *McClure's pit* is 1178′ A. T. And again a couple of hundred yards east, in Locust knob, in the very top of the hill at about 1170′ A. T. The dip is strongly south-east here, for at Jno. Christy's, a little over half-a-mile south-east, facing the Youghiogheny, the coal is 1125′ A. T.; at Andrew Christy's, back of the school house 1060′ A. T., and at *Osceola mine*, along the Westmoreland line only 955′ A. T.

Between branches of Jack's run, and close to the Westmoreland Co. line, the map will show several small areas.

Jas. McClintock's coal is 1150′ A. T., and with the rest of the coal here is dipping strongly south-east into the Lisbon (Irwin) synclinal trough, of which they are merely outliers in Allegheny Co.

Throughout all this portion of the field the coal is quite irregular. Horse backs, soot-veins and kindred troubles rarely occur, though clay veins, running in every direction from 3″ to 6″ wide, are frequently met with. Swamps are reported in the Keystone works and also appear across the line in the *Larimer mines* of the Westmoreland Coal Co. The principal trouble arises from swellings from the main clay parting, causing sudden variations in the size of the coal. Near the clay veins, too, the coal is found twisted, in places for a considerable distance.

The amount of cover of the Upper Productive Measures is generally light. The highest rock exposed is a portion of the Great Limestone, seen along the Greensburg pike south-west of the old toll house. It is thin however and imperfectly exposed, though yielding a fair quality of lime. Neither the *Redstone* or *Sewickley* coals could be located, though their horizon was reached in several places.

The lower Barren Series are widely exposed, filling up all the country below the Pittsburgh coal outcrop.

Opposite Brinton station, on the south side of Turtle creek, there is quite an extensive quarry in the Morgantown sandstone, here a fine gray building stone 30′ thick. About 30′ below its base there crops a prominent band of red shale 20′ thick nearly to the level of the creek and railroad, and carrying the Crinoidal limestone above it.

The same measures crop at Port Perry, and eastward along the P. R. R., though somewhat lower measures are brought up in the latter direction by the Roaring Run axis. Along the Youghiogheny almost the entire series is brought up along the axis near Long Run sta, a well sunk here near water level being reported to have reached the Upper Freeport coal at 160′. Still as the Crinoidal limestone is not greatly above water level here (being well seen at Elrod Sta.) this may have been a small coal bed found about 25′ *above* the Mahoning sandstone and consequently *higher* than the Upper Freeport coal. The *Barton coal bed*, above the Crinoidal limestone, is also seen on the Youghiogheny, and the Morgantown sandstone as well, though in this portion of the district rather flaggy and not so valuable as along the Port Perry section.

A full description of the three townships of Allegheny Co. lying between the two rivers, viz: Lincoln, Elizabeth and Forward, will be found in the Annual Report for 1885, and need not be repeated here. The outcrop of the Pittsburgh coal bed and its relation to the Roaring Run or Murraysville anticlinal, is clearly shown on the map.

3. *Southern and Western Allegheny Co.*

This, the third geographical division of the county, has already been described as comprising that portion of the county lying south and west of the Ohio and Monongahela rivers. It may be further sub-divided for treatment *geologically*, into west and east portions by Chartiers and Robinson creeks, parting the district almost in half.

The map coloring will show how, north of this division line, the *Pittsburgh coal bed* and the overlying Upper Productive Measures are confined to the hill tops; in long narrow strips cut off from each other by the erosion of Robinson and Montours creeks; with the underlying Barren Measures occupying more than one-half of the district.

Geology and topography, no less than the location of the Pittsburgh, Cincinnati and St. Louis R. R. (Pan-handle) trunk line along the dividing line of the district, have combined to confine developments, in the western half, to the neighborhood of Chartiers and Robinson creeks. The Imperial Coal Co. alone mine coal from along Montours' run by a private railroad eleven miles long, running from the P. & L. E. R. R. on the Ohio to Imperial.

The eastern portion of this district is characterized by a much wider and less broken outcrop of the Pittsburgh bed; consequently a large area of the Upper Productive Measures, and along the Washington Co. line in Upper St. Clair and Snowden townships, a covering of the Upper Barren Series with the Pittsburgh coal far beneath water level. This portion of the field is developed by the Pan handle R. R. and its Chartiers Valley branch, and the Pittsburgh, Chartiers and Youghiogheny R. R. on the west; the Wheeling division of the Baltimore and Ohio R. R. in the centre, and the Monongahela division of the P. R. R. on the east, possessing besides the advantage of a splendid river front along the Monongahela. Several private railroads likewise contribute to the development of this section which furnishes by far the largest part of the county's coal production.

The structural features of this part of the county are briefly:

1st. The great *Pin Hook anticlinal axis* on the east, entering from Washington Co. about 4½ miles from the Monongahela river near the 12 Mile house on the Brownsville road on a course of about N. 30° E.; crossing Lick creek and the B. & O. R. R. about ¾ miles above Cochran's mills; reaching the Lebanon church and school house in Mifflin township, and thence to the river below Green Springs sta., opposite Braddocks. Its rate of rise northeast in Allegheny is very slight, the Pittsburgh coal on its crest being about 1025′ A. T. on the Washington Co. line, and 1075′ on the river bluff, the two points being about 10 miles apart.

The *Roaring Run* (Murraysville) *anticlinal* barely touches the eastern edge of this district, crossing the Washington Co. line about ¾ miles from the Monongahela and hugging that river closely to its crossing near Blair station on the P. V. and C. R. R. (Monongahela Division P. R. R.)

2d. The *Washington anticlinal axis*—a very important roll, entering from Washington Co. about a mile west from Chartiers creek; crossing the Chartiers Valley R. R. above Hastings sta.; McLaughlin's run near McMillan's coal bank; Painter creek between the Essen and Harrison mines; through Mt. Lebanon in Scott twp. and along the Washington pike to the borough of West Liberty, north-east of which it subsides in the great plateau facing the Monongahela river. If continued in its course it would strike the river near the Birmingham bridge.

On Chartiers creek, the Pittsburgh coal on the crest of this anticlinal is about 825′ A. T. The north-east rise in this axis is sufficient to lift the same bed to 1030′ A. T. on the river, the distance between the two points being about 9½ miles or a rate of *nearly* 22′ per mile.

The map will show how all connection is broken off between this axis and the *Brady's Bend anticlinal*. The latter, curving southward after passing Girtie's run in Ross twp., touches the Ohio at the mouth of Woods run, keeping its new course, while subsiding rapidly, across the Panhandle R. R. close to Sheridan station, and dying in the high summit east of Grafton sta.

The *Waynesburg synclinal*—or more properly its western division,—enters from Washington a little less than 2 miles from the Monongahela; crosses the P. V. & C. R. R. near Rock Run sta., and then practically follows the river to Port Perry. It is exceedingly irregular and sinuous.

The Pittsburgh coal rises north-west from the trough about 25′ per mile on to the Pin-Hook axis, which lies next west.

The *Mansfield synclinal*, lying west of the Washington axis, seems to be, as far as developed, a single trough, curving and shallow and in great measure following Chartiers creek *approximately*, from the river to the mouth of Thom's run. It passes through the town of Mansfield and crosses Miller's run about ¾ miles from Chartiers creek and thence passes south-west through South Fayette to Washington Co.

To the north-west of the Mansfield trough there is practically no cessation in the north-west rise of the measures that can be detected by barometric leveling as far west as Robinson's run.

The *Claysville axis*, if present at all within Allegheny Co., must pass through the area of Barren Measures eroded by Robinson's creek—at least between Oakdale and the Washington Co. line. This line, if continued north-eastward, would pass just east of Seneff's Summit Hotel, on the Steubenville pike, and reach the Ohio river in Stowe township a little below Davis' Island.

The axis at best is very feeble, and while my surveys do not entirely warrant its location along this line, there are several significant facts in favor of its presence here.

In the first place the north-west rise of the Pittsburgh coal bed through S. Fayette township, from the Mansfield basin to the Panhandle railroad (about 50′ per mile) would, if continued west of Robinson's creek, be great enough to carry this coal and some of the barren measures above the hill tops. Very few summits along the Steubenville pike reach to over 1200′ A. T. and even allowing that general elevation, the Pittsburgh coal would be *at least* 50′ in the air, based upon the initial rate of rise from the Mansfield trough.

But in point of fact, this north-west rise seems to cease along Robinson's run. The coal is no higher on the west side of the railroad than on the east, though cut out by erosion well back from the creek. And along the north branch of Robinson creek, it is *generally* at a *lower* level than on the main creek.

North-east of Oakdale, along Pinkerton's creek, the country is greatly eroded and all signs fail; but at Summitville, the coal, while quite flat, shows a slight inclination *away* from a line passing north-east and south-west near the hotel. To the west, Bell's coal is at 1095′ A. T.; Andrew's 1085′ and Phillips' 1090 A. T.; and the map will show the relative position of these three pits.

East of the line and hotel Edmunson and McCormick's coal are each at 1085′ A. T. on opposite sides of the pike, while the measures are undoubtedly dipping south-east from here towards Remington where the coal is at 1030′ A. T. The same features show in the extreme northern patch of Pittsburgh coal, in Stowe twp., and while in each case it must be confessed that the differences are slight for barometric observations, it is fairly possible that more accurate instrumental surveys will emphasize these differences, and definitely extend the *Claysville anticlinal* through this part of the field.

The *Bulger anticlinal*, which is plainly marked crossing the Pan-handle R. R. at Bulger station in Washington Co., is an extremely insignificant axis and shows even less data for its location in Allegheny Co. than the Claysville. Time and opportunity were wanting for a close examination of Findlay and Moon townships of Allegheny, where the Pittsburgh coal, though patchy, still exists in places.

In the absence of any reliable datum plane, it is highly improbable that a series of barometric observations would have sufficed to give very reliable levels, especially where the dips at best must be very slight.

Still, from the preservation of the Upper Productive Measures at all through these western townships along the Washington line ; at Clinton ; Sharon and Beers, we might naturally infer a cessation, if not a reversal, of dip along the line of Montours run.

At the Montour mine of the Imperial Coal Co., the initial dip of the coal is to the *north-west*, the coal rising south-eastward *at least* as far as the Steubenville pike, before the dip is reversed towards Robinson creek.

In the Cliff mines, of the same company, located about 2½ miles further *east*, the natural dip is to the south-east, and the anticlinal (if it exists here at all) lies nearer the railroad and run.

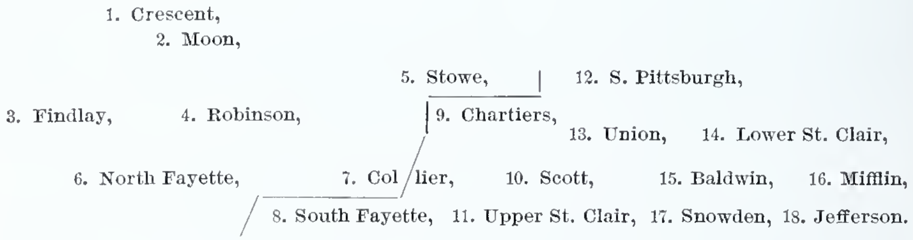
From here to the river, the Barren Measures are everywhere the surface rocks ; but it is quite possible that the long strip of coal in Moon twp. is due to the north-west dip of the measures in the vicinity of Beers P. O.

Much closer work will have to be done to determine the presence of the Bulger axis in Allegheny Co., and the economical importance of the coal measures hereabouts did not seem to warrant the expenditure of the time necessary to settle the point. At present it can only be said that there are indications of a gentle anticlinal entering Allegheny Co. about 4 miles north-west of the Claysville axis (or Robinson's creek) and about 1 mile south-east of North Star P. O. on the Steubenville pike; that evidences of its existence show in the Montour mine at Imperial; and that if extended on this line from Bulger, it would reach the Ohio river at or near Middletown.

The *synclinal* trough occurring between these two axes—the *Claysville* and *Bulger*, is both shallow and narrow as well as indistinct.

In Washington Co. this trough is visible on Buffalo creek and as far north as West Middletown. It should cross the Panhandle R. R. near McDonald Sta. and enter Allegheny Co. along the north branch of Robinson creek. The coal certainly rises each way from the creek, though the basin is extremely gentle and nowhere in this county buries the Pittsburgh coal beneath water level. North-eastward it becomes insignificant, but probably merges into Montour run in the vicinity of Trout run and may be associated with the slight basin already located on the north side of the Ohio river, just below the mouth of Killbuck creek in Alleppo township.

The general arrangements of the different townships and their west and east sub-divisions in this district, is somewhat as follows:



Robinson creek cuts Collier township nearly in half; elsewhere, with Chartiers creek, it makes a natural boundary between the townships.

Montour's run, rising along the Washington Co. line, near North Star, not only separates Findlay and North Fayette, Moon and Robinson, but largely drains those townships. Northern Moon is drained directly by small runs into the Ohio, while southwestern Findlay is watered by the Potato Garden and Raveden runs, branches of Raccoon creek, finally entering the Ohio opposite the borough of Cleveland.

Chartiers creek and its chief tributary, *Robinson creek*, complete the drainage of Stowe, Robinson, Collier, North Fayette to the west, not otherwise drained by Montour's run or the short river streams; all of Chartiers on the east, and the western half of Union, as well as the larger parts of Scott and Upper St. Clair.

If to this area we add that of Washington Co. it will be seen what an important part these streams have played in shaping the topography of the country through which they now so peacefully and gently meander.

Saw Mill run is next east, and though but short in comparison with the other large streams of southern Allegheny, its rapid fall makes it one of the most dangerous and destructive at times of high water. It has also played a leading role in the past in determining the present topography of the district through which it flows, assisted in a measure by the presence of the Washington anticlinal. Its erosion within the city limits of South Pittsburgh has been something enormous and has created bluffs nearly as high and steep as along the river itself.

It drains a considerable portion of Baldwin township and the city of Pittsburgh.

Beck's run, dividing partially Lower St. Clair and Baldwin, drains portions of each township, while *Street's run* entering the Monongahela near the B. & O. R. R. bridge does a like service for Baldwin and Mifflin.

Thompson's run drains north-east Mifflin, otherwise watered by short streams falling from the Pin Hook anticlinal directly into the Monongahela.

Peter's creek is the only remaining stream of importance in the district. It empties into the Monongahela between

McKeesport and Elizabeth, and with its several branches—Lewis run, Beam's run, Lick run, and Piney fork, it drains nearly all of Jefferson and Snowden townships.

It has cut out for itself quite a wide channel in the Barren Measures in Allegheny Co.

Moon township lies along the Ohio river, between Robinson and Findlay, joining Beaver Co. on the west.

The extreme northern corner is occupied by Crescent twp. with the borough of Shousetown on the Ohio.

The rocks exposed belong for the most part to the Barren Measures, extending for 500 feet beneath the Pittsburgh coal ; while there is nowhere over 75 feet of a covering of the Upper Productive Series. Of this upper series, there are no exposures of the individual rock strata, all the measures being greatly decomposed.

The most important area of the *Pittsburgh coal* extends from the neighborhood of Sharon south-east for about 4 miles, cropping on both sides of the ridge road.

At Sharon the lower division of the bed is alone exposed and shows a parting in the breast coal as follows:

Coal,		10″	5′ 10″
Parting,		1″	
Coal,	2′	2″	
Bearing-in coal, and bands,		6″	
Brick *coal,*		9″	
Lower bottom *coal,*	1′	6″	

In some banks here the bed is thinner than this section. North of the village the coal is eroded, the country falling off rapidly towards the river, although quite an area is preserved between the forks of Narrows run.

On the road leading east from Sharon to Ewing's mills on Montour's run, occasional patches of the coal are caught to a little way beyond the first cross roads, so that the outline, as shown on the map, is merely approximate.

"About two miles south-east from Sharon, on the ridge road, the coal is mined by Mr. J. McCormack, at whose bank it shows :

Roof division, 3 feet 9 inches ; clay, 10 inches ; lower division, 4 feet 10 inches ; total, 9 feet 5 inches.

The parting in the upper bench of the lower division is present here. and divides that bench into two nearly equal portions, the total thickness being two feet eleven inches. The roof division shows three feet of coal in four benches, all of which is bony. The coal from the lower division is caking, leaves little ash and has but a small proportion of sulphur. On the same road, and south-east from this opening, is one belonging to Mr. Nolte, at which the section, as far as exposed, is as follows:

Roof division, seen, 1 foot: clay, 1 foot 6 inches; lower division, 4 feet 7 inches.

The roof division is not far from four feet thick, as appears from the blossom. The partings in the lower division are unusually thick, and the lower two benches cannot be distinguished. At a little distance further south-east Mr. McCormack mines the coal, which there shows a section like the last. This is the end of the area, and the surface falls thence in all directions towards Montour's run." (K. p. 330.)

The numerous streams of the township have cut deep trenches into the Barren Measures; but in nearly every instance the exposures are unsatisfactory.

The old river channel has covered all the northern part of the region with sand and débris for three miles back from the present front.

The Crinoidal limestone is present on both forks of Meek's run where the Middletown road crosses them as well as in the bluffs along Montour's run.

It has already been stated that the *Bulger anticlinal* possibly exists along a north-east and south-west line, passing from the vicinity of Beer's P. O. towards Middletown on the Ohio river.

Findlay township lies next south of Moon, with Beaver and Washington counties on the north-west and south-east and Montour's run for a south border line.

On the high divide, near the centre of the township, between the waters of Raccoon and Montour's creeks, the *Pittsburgh coal* is caught around Clinton.

Here it is mined at several places. The outcrop (which is only approximately located on the map) is exceedingly irregular, one arm extending out from the main body north-eastward in a narrow strip to within half a mile of the Moon twp. road, and a small outlying, detached area bordering on that township.

The outcrop is everywhere accessible, owing to the fact that nearly all the streams of the township head around this summit. The ridge itself rises to 130 feet above the coal, giving good cover and firm coal.

At Irwin's pit, just west of Clinton, the coal shows:

Roof division,	4′	8′	10′
Clay parting,		1″	
Lower division,	5′	3′	

The section is somewhat abnormal. The breast coal is here 3′ 8″ thick, although in this part of the field it rarely exceeds 2′ 9″. The main clay parting is exceedingly thin, though this is fairly local.

The bottom bench of the roof coal is taken down, though bony.

The coal, on the whole, is rather soft, free burning and is highly thought of. Neither clay veins nor horsebacks in the lower coal are met with in the mine.

To the east of Clinton, the Pittsburgh coal is mined by Mr. Twyford, and others. Here the lower division is somewhat thinner than at Irwin's and the coal is excellent.

South of Clinton the crop extends for nearly a mile. Mr. McCullough has opened the coal and turns out good fuel.

A small area is also left in the south-east corner of the township, about ⅔ miles north-west of McClarn's mills. *Tomlinson's* bank here shows:

Roof division *coal*,	3′	2″	8′ 8″
Main clay parting,	1′	0″	
Lower division *coal*,	4′	6″	

The coal is good here too; softer than the coal east from here; but excellent for steam purposes. It is free burning and leaves no clinker in the ash.

In the southern part of the township, the coal is opened at J. M. Stewart's, where the lower division is 4′ 5″ thick. Clay veins and horsebacks are frequently found here.

Again, about a mile from North Star, the coal is opened at J. Cox's bank, where the following section was obtained:

Roof division,	5′ 10″	11′ 7″
Main clay parting,	1′ 0″	
Lower division,	4′ 9″	

The roof division contains coal and clay in nearly equal divisions and in thin layers.

About 1½ miles from here, on the same road, the coal is opened by Messrs. Hays and Auld.

Many other openings have been made in the past, but they are partially closed and present no new features. The township will never be important as a coal centre owing to the limited amount of the Pittsburgh coal left. The Barren Measures are exposed 200′ below the coal.

Robinson township is an irregular L shaped area extending from the Ohio river, east of Moon, south to Collier township, and east to Stowe and Chartiers creek. The latter creek makes its south-east border from the line of Stowe to and beyond Mansfield.

The P. C. & Y. R. R. follows this stream and passes through the township as far as North Mansfield before crossing to the east side of the creek. The Panhandle R. R. also skirts its south-east border line, crossing the P. C. & Y. R. R. at North Mansfield and running in the township to the Collier line.

Campbell creek, a branch of Chartiers, hugs the south line of the township, rising in the south-east corner and flowing south-east to Mansfield.

The northern part of the township drains directly into the Ohio, through Montour and Moon runs.

Stowe township which occupies the corner between the river and Chartiers creek, can be conveniently treated as a part of Robinson, *geologically*. It only has an insignificant area of Upper Productive Measures at its south side, fully seven-eighths of its area being occupied by Barren Measure rocks. The P. & L. E. R. R. skirts along its river front and the P. C. & Y. R. R. occupies a portion of its extreme eastern border. It is greatly eroded and the river wash extends well up its north and east flanks.

The *Claysville axis*, if continuous this far north, will be found to pass through the centre of Robinson township, crossing the Steubenville pike at Summitville, and thence through Stowe to the river. From here all the coal dips southeast into the *Mansfield synclinal* along Chartiers creek.

In the small area of coal left west of Summitville, the dip is scarcely noticeable, though slightly inclining *towards* Montours run.

The geological section exposed extends from about 250 feet above the *Pittsburgh coal* to 450 feet below it. The coal does not reach *north* as far as the road leading from Ewings mills on Montours run south-east towards Chartiers creek, so that all the northern part of the township, draining to the river, is occupied by the Barren Measure rocks.

The same rocks are exposed along both branches of Campbells creek, nearly to their source.

At the forks of this stream, a massive sandstone shows, the top of which is about 40′–50′ below the *Pittsburgh coal.* Portions of it are quite solid and would make an excellent building stone. The same rock is very extensively quarried along the Panhandle road above Walker's mills.

The *Crinoidal limestone* shows on Chartiers creek at the crossing of the Pittsburgh and Steubenville pike, 285′ below the coal.

The openings in the Pittsburgh coal are numerous. The bed is quite solidly held all through the southern portion of the township except where the principal streams have cut it out. Facing both Montours and Chartiers creeks it lies well up in the bluffs, being relatively lower along the Panhandle railroad than anywhere else in the township.

The western crop, entering from North Fayette, heads around the ravines north of the pike, nearly reaching to the intersection of the pike and the Clinton Grade road. Here at some distance vertically below the road, the coal is opened at *J. M. Bell's* pit, 105′ feet lower than the Summitville hotel and at about 1095′ A. T. The breast coal here is 3′ 6″ thick ; bearing-in coal, 3″ and the brick coal 10″. The lower bottom coal could not be measured, as the pit was filled in with mud and water and idle.

Directly north-west across this hill, and on the *north* side of the Clinton road, the coal is opened at *Mr. Andrews* pit 10′ lower or at 1085′ A. T. This pit was also idle and its exposed section quite similar to Bell's.

Along the road running south-east from school house No. 5, and just at the head of the ravine, an abandoned opening of *Phillip's* shows close to the road at 1090′ A. T.

The outcrop swings northward from here around a prominent flat knob of country and returns again nearly to the forks of the road at the school house. In this ravine and hillside the coal is opened at *John Phillips country bank* at 1105′ A T. Considerable coal is run out from here during the fall of the year. The lower division is about 5 feet thick.

The crop crosses the road south of Fitzsimmons house and after passing around the hill at Wm. Phillip's, extends far south and south-west along Moon run, to the meadow north of the Summitville hotel.

North of the pike it is opened well down towards creek level, at *Wm. Edmundson's* 1085′ A. T. on the south side of the creek. The outcrop is cut out by a small branch of Moon run, heading up to D. Clever's, where the map will show three isolated areas cut off from the main body and in *Stowe township*. In the southern one of them is an abandoned opening just east of Clevers house at 1090′ A. T. North from this, in a clover shaped patch, the coal extends about half a mile east from the forks along the Middletown road, finally cropping at 1120′ A T.

From here it extends north-west, just back of school house No. 3 (*Claysville anticlinal?*) and crops close to the cross roads at 1105′ A. T. or 15 feet lower, than on the Middletown road. The third patch is immediately west of Jas. Speers at about the same elevation as the last, where the lower division is 4′ 4″ thick and main clay 1 foot. Returning to the main body, the coal is greatly eroded facing Chartiers creek at the big bend and is confined almost entirely to the narrow ridge along which the road runs to the pike. It was formerly opened here at *L. Fritch's bank* at 1080′ A. T. The crop crosses the pike just at the village of Remington at 1030′ A. T. where it has been quite extensively opened at the *Coleman Company's pit*. The bed is but partially exposed here and shows about 1 foot of roof coal; 1 foot of main clay parting and 5′ 6″ of lower division coal, clean and good.

Here also, at 60 feet above the coal there is a bituminous shale (*Redstone coal*?) resting upon limestone and the first summit on the pike beyond the Glass Road just catches the *Sewickley* (?) *coal* on top of limestone at 110 feet above the Pittsburgh coal opening.

The Pittsburgh coal does not reach up the pike quite as far as the Glass Road; but on the Campbell's creek side of this road it crops at 1030′ and extends up the north fork of the creek to *H. McCormack's* at 1085′ A. T. Along the south or main fork of Campbell's creek, the coal crops to within half a mile of the pike, rising north-west about as fast as the stream.

It is opened at *Lloyd's pit*, south of Palmersville at 1085′ showing Main clay 11″; Breast coal, 2′ 9″; Bearing-in, 3″; Brick coal, 9″, and Lower Bottom, 1′.

The coal rises slightly for about ¾ miles south-east going down stream; but afterwards dips constantly and regularly down the run into the Mansfield synclinal. It is opened at *H. Glass' pit* on a small branch heading north from the main stream at 1010′ A. T.

In the south-eastern portion of the township, between Campbell's creek and Chartiers creek, almost all of the coal territory is owned by the *Mansfield Coal and Coke Co.* Their No. 1 mine workings are located here, and extend north-westward to beyond school house No. 1 on the Baldwin road. Facing Chartiers creek the coal is about 910′ A. T., and well up towards the hill top. North-west the coal rises regularly about 50′–60′ per mile and drains naturally—south-east along butt entries and south-west on the face entries—to daylight. The slack from this mine is washed and coked in 27 ovens, making a good though soft coke, largely used in the western markets for foundry and mill purposes. All the front coal is worked out, the present working pit mouth of the company being reached by a surface road half a mile long up a small ravine from the tipple.

The coal here shows the following variation in section:

Roof Division,	Roof coal, ...	2'+	
	Main clay slate, . . .	1' to 9''	
Lower Division,	Breast coal, ...	3½' to 3'	6' 7'' to 4' 2''
	Bearing-in coal, . . .	7'' to 4''	
	Brick coal, ...	1' to 9''	
	Lower Bottom, . . .	1½' to 1'	

The exposures above the coal are largely concealed throughout the township.

North Fayette township is a large area lying along the Washington Co. line, south of Findlay, and with Robinson creek and Pinckerton's run separating it on the east from South Fayette and Collier townships.

The Montour's Run railroad skirts the northern edge of the township, being alternately in this township or Findlay, according as the run is crossed, as far up as Imperial. It is only a local road used for transporting the products of the Imperial Coal Co. to the P. & L. E. R. R. and to the Ohio river tipples.

The Panhandle railroad runs along Robinson creek, thus giving transportation to the south-eastern portion of the township.

Robinson's run, and its tributaries, the North branch and Pinckerton's creek, drain four fifths of the area.

The geological section of rocks exposed, extends for about 200 feet above and below the *Pittsburgh coal.* As a general rule the covering of Upper Productive Measures is light, except in the vicinity of the Steubenville pike, which runs along the north side of the township, almost everywhere from 50 to 100 feet above the coal. Still higher ground lies immediately south of the pike, though at all places the exposures are obscure.

Between Shirland and North Star, two limestones crop on the pike, respectively 30 and 60 feet above the coal; and at the school house, east of North Star, the lower division of the Great Limestone is exposed, 100' above the coal.

South from here the country rises to 200 feet above the coal, taking in the horizon of the *Waynesburg coal.* It has already been stated that hereabouts the level of the Pittsburgh coal indicates the presence of the Bulger anticlinal, crossing through the Montour mine openings and bending the front coal, overlooking Montour's run, to the north-west. At best its effect is quite insignificant and its actual presence is only problematical.

So likewise with the Claysville axis in the southern part of the township, whose presence is inferred from a cessation in the north-west rise of the measures from Chartiers creek, and the reversal of the dip between Robinson's creek and the North Branch.

The developments upon the Pittsburgh bed are meagre in comparison with the extent of outcrop shown on the map. It is everywhere available by reason of the erosion of the many streams; but mining operations are entirely confined to the north part facing Montour's run, where the two mines of the Imperial Coal Co. have opened the crop quite extensively.

The country immediately north of Robinson creek is greatly eroded and exposes about 200 feet of the Barren Measures. The outcrop of the Pittsburgh coal is thus thrown well back from the railroad and this fact, together with its dip towards the north-west, has pobably prevented its development north of the Panhandle railroad.

Along the pike it is opened at several country pits. At Shirland P. O. the coal is opened, showing about 5 feet of the lower division with a double "bearing-in" bench. About a mile further east along the pike in the neighborhood of Fayetteville, the coal shows:

Roof Division,	6	7′
Main clay parting,	1	0″
Lower Division,	3	11′+

Only three inches of the bottom coal could be seen here and the mining coal averages about 3′ 8″.

A mile west of Shirland, the coal is extensively worked at the *Montour mine* of the Imperial Coal Co., at 1110′ A. T.

The coal is planed down to a surface road running up a small ravine from the main road along Montours run. All the front coal here dips and drains north-west, rising south-east about 25 feet to beneath the pike, and then dipping in that direction steadily to Robinson's creek.

In this mine the breast coal varies from 2′ 8″ to 3′ and brick coal from 10″ to 1′. The bed yields from 3′ 8″ to 4′ 10″ of coal and the average run (August, 86) is about 300 tons a day.

The mine is located well up on the hill and but little below the pike. It is extensively equipped with an improved system of wire rope haulage, by which cars can be placed in whatever part of the mine they are needed without stopping the engine. This is effected by a lever movement, the rope moving all the time, and returning around a set of bull wheels inside the entry. The rope is endless and moves along a double entry, in one direction constantly. The main entry of the mine is driven double for 4500′ to the rear property line on a face of S. 22–25° W. Between these two there is a middle tunnel 350′ long for dropping coal. Two dillies running along the outside entries bring the coal to this point, so that all the coal going down the plane is conducted along the middle tunnel.

From the pit mouth to the bull-wheel at the turn of the endless rope is 3311′. All the mine work is by single entry, except main tunnel. All the coal in front of No. 4 butt entry drains north, out of pit mouth, while that *west* of the main entry, back of No. 4 drains south-east, and is eventually carried back to a rear drain punched through above the crop in a ravine south of the pike. A swamp extends through the east works draining and deepening *southwards*. No. 5 butt entry meets it 350′ from the main gangway ; No. 9 butt at 800′ and No. 13 at 1050′. Comparatively little work has been extended beyond this swamp, eastward. Air courses are about 150 yards apart and the mine is generally in good shape. The combined output of this and the Cliff mine of the same company in 1885 reached 110,721 tons.

The crop touches the Steubenville pike east of this run at 1130′ A. T. and then passes north-east around the hill to Shirland.

The coal is opened along the pike at A. McBride's about 2 miles east of the Montours Presbyterian church.

There the bed shows: roof coal 4′ 6″; main clay 1′; lower division 4′ 9″; total 10′ 3″.

The breast coal is about 2′ 10″ thick and contains some iron pyrites. It breaks out in handsome blocks and is uninjured by clay veins.

The *Cliff mine* of the Imperial Co. comes next east and is located but a short distance north of the pike in the hill overlooking Montours run. It is connected with the railroad by a lateral from Cliff Mine Sta. 13 miles below Imperial.

All this coal lies south-east of the *Bulger anticlinal* (?) and properly dips south-east. It should all be drained at the rear end by drifts into branches of Robinson run, although at present the company choose to pump largely. The main entry (on face S. 25° W.) passes under the pike about 800 feet from the pit mouth. The latter is 1095′ A. T. The coal is good. One short swamp has been met with in the north-east side workings, which is drained northwards. The breast coal is 3′± thick, brick 10″; output (Aug. 1886) 400 tons a day.

The same system of mining is pursued here as at Montour mine, both mines belonging to the same company.

The wire rope haulage system however has not yet been introduced, and the middle tunnel therefore was not used.

It would appear perfectly feasible to drain this entire mine by extending some one of the rear butt entries, as No. 13, to Robinson run waters at McKees hollow. As it is, there is a shaft striking main entry 2950′ in from pit mouth, where a large part of the drainage is collected and pumped to the surface.

All front coal is drained by an artificial ditch, in front of butt entries Nos. 4 and 5. Up to August 1886, about 13 butt entries had been turned off the main gangway averaging about 150 yards apart.

No. 1 butt, turned eastward 400 feet from pit mouth, had been extended 2600 feet to daylight. No. 3 butt, on same side, went 2350′ to daylight; 100′ across a ravine and 500′+ into next hill. The other entries have not been extended so far. No. 4 is 1600′ long on west side of main tunnel.

Nos. 13, 4 and 6, were being most actively worked in August 1886.

The railroad tipple is arranged with a revolving cylinder, turning 180°, upon which the mine cars are run, three at a time, and held firmly while being reversed, throwing in to 3 sets of $\frac{3}{4}''$ screens.

The output here for the year 1885 is reported in the total of the Montour mine.

The coal crops on road leading to Steubenville pike at 1090′ A. T. and is next opened near the Robinson Twp. line just north from the church at Stewarts pit at 1100′ ± A. T. Here the roof division is 5′ 10″; main clay 1′; lower division 4′ +.

Along road leading from the school house on the pike towards Oakdale, the coal crops opposite W. McKees at 1080′.

No. 13 butt entry of the Cliff mine should have been extended a little beyond their south property line and out to this point, obtaining natural drainage and ventilation and doing away with the necessity for pumps.

The Pittsburgh coal crops along road for some little distance and is finally opened at Alex. Campbell's pit, just beyond the forks on the left side of the road at 1060′ A. T., and from here, *rising* slightly south-east.

Above the old saw mill, on a feeder of the north branch, the coal shows in the road, east of Jno. Robb's at 1046′ A. T. The coal has about 50 feet of cover on the ridge here; but the ground is sloping and apt to give considerable "red" coal. The Morgantown ? sandstone crops along the stream here, down to the stone bridge, and is largely quarried at the forks of the road at 1035′ A. T. The coal lies high in the hill here.

The north branch of Robinson's creek has eroded the country through which it flows, to a considerable extent.

At Geo. Gormley's, on the road to Oakdale, the Pittsburgh coal is opened well up the hill, on south side of stream, at 1045′ and evidently dipping north-west, as it crops at a somewhat higher elevation on the south side of this ridge, facing Oakdale. Near the Washington Co. line, the south-west slope of the measures has brought the coal closer to the stream. On the first branch heading up towards North Star, the coal is opened about 1 mile north of the north branch at *S. P. Mevey's country pit*, about 40′ above the run and 1055′ A. T. The hills here are quite solidly underlaid with coal. The crop crosses the road and is opened. 400 yards north of Mevey's, at *Mr. Wilson's pit* at 1070′ A. T. taking cover in about another half mile. This same rate of rise, now north-west towards the Bulger anticlinal (?), is seen on Half Crown run—the next branch east from this.

Directly across from Wilson's, it crops on the connecting road at the new school house at 1070′ A. T. and again just above the main road at the old school house.

On the Half Crown road, ¼ mile up from the school, it is opened at the *Crook's pit*, along side road at 1080′.

The crop continues up to beyond where the road crosses the stream, the road keeping about on the bottom limestone, until opened again at *A. Crook's pit* at 1095′ A. T. The coal takes cover beyond the forks of the stream at the church at about 1100′ A. T.

The road rises rapidly then to the pike at Crook's house at 1210′ A. T.

The pike from here to the Imperial road varies little from this elevation and frequently shows outcrops of a (Fishpot ?) limestone in the successive summits passed.

Collier township is an irregular shaped area, wedged in between North Fayette and Robinson and with Chartiers creek and Thom's run for east and west boundaries. It was formerly shown as a part of Robinson on the old county map, and geologically it is, in all respects, quite similar. The south half belonged to S. Fayette.

Robinson's creek and the Panhandle railroad run through it from west to east, a little south of the centre, and the Thom's run branch of the P. C. & Y. R. R. helps to develop a valuable field of coal along its southern edge.

The Chartiers Valley branch of the Panhandle extends along that creek, though mainly developing the townships to the east of it.

The coal area north of Robinson's creek and the railroad, is somewhat cut out by the long branches of that creek, heading well up to the north township line. South of the railroad the coal is almost solid in Thom's run, the south-west slope again assisting here to bring the coal well down to creek level.

On Thom's run the crop extends to within half a mile of the west township line, and dips uninterruptedly south-east from here into the Mansfield synclinal.

The latter just enters the south-eastern corner of the district, while the Claysville anticlinal just touches the north-west corner. Formerly this axis had been made to pass through Hay's Sta; but I think there are sufficient reasons for placing it nearly two miles further west.

The geological section exposed in this township extends from about 200′ above to 400′ below the Pittsburgh coal.

The principal coal developments are of course along the lines of the two railroads, one of the latter having been especially constructed to develop land along Thom's creek.

What facts could be gathered concerning these operations have already been presented in a former part of this report.

Though the line of development was carefully gone over from Mansfield to Greggs Sta. not a single mine along the Panhandle road was working on the day of inspection in August, '86, and many of the mines were entirely bereft of any person in authority.

At the eastern end the *Grant mine* (Grant Coal Co.) is opened about 110 feet above the railroad at 885′ A. T.

This is close to the Mansfield synclinal, and all the coal to the north-west drains out of the pit mouth or south-west into the ravine heading up back of the workings.

The elevation of coal at the place of taking cover in this ravine is 980′ A. T., about 1¼ miles from the pit mouth and near J. Cully's.

The breast coal at the Grant mine will not average much above 2′ 10″; bearing-in 3″ and brick coal 8″, yielding about 3′ 6″ of coal. The lower bottom, 1′ thick, is not raised. The output in 1885 reached a total of 48,854 tons.

The *Camp Hill mine* (D. M. Steene) is next west along track, opened on south side of creek, well up the bluff at 830′ A. T.

The main pit mouth is about 75′ above main track, while a surface road connects this pit mouth with another opening on the east side of the hill at 825′ A. T.

These are very old workings and there are only about 6 acres of coal left out of a tract of 200.

The mine is drained out near the poor house, right in the basin. In 1885 the output reached 26,100 tons.

The *Fort Pitt mines* (Fort Pitt Coal Co.) comes next west, and are about half a mile below Walker's mills, on the north side of the creek. A siding reaches the tipple from the main line, and a long incline over the public road leads to the pit mouth at 920′ A. T.

This company mined coal in the ridge lying east of Scott's run. The mine seemed to be abandoned, although in 1885 35,000 tons were mined here.

The coal crops out in long prongs between the streams, which cut down deeply at their mouths into the Barren Measures.

On Scott's run, nearly 1½ miles from Walker's mills, the coal is opened at Dr. Smith's at 1040′ A. T., rising rapidly north-westward. This pit was in a very dilapidated condition, making it impossible to get any measurements of the coal.

Near the head of the run the coal is mined by Mr. W. McLaren where the coal shows as follows:

Roof coal, 5′ 11″; Main clay, 1′; Lower division, 5′ 4″; total, 12′ 3″.

The following section of the measures and comments are given from Rep. K., p. 324, taken at a time when this region was in active operation:

“1. Concealed,		60′ 0″
2. Sandy shale,		15′ 0″
3. *Pittsburgh Coal Bed.*		
Roof division,	5′ 10″	11′ 10
Clay,	1 0′	
Lower division,	5′ 0″	
4. Limestone,		2 -4′ 0″
5. Concealed,		15′ 0′
6. Limestone,		Fragments.

7. Sandstone,	15′ 0″
8. Concealed,	10′ 0″
9. Sandstone to track,	65′ 0″
Sandstone below track,	10′ 0″

"The coal here is extensively mined for shipping and seems to be very good, except in the bottom, which is not taken out. The roof has at its base a bench of coal twenty-eight inches thick. Horse-backs occur occasionally and clay-veins are very troublesome. The latter vary from two to five feet in width."

The *P. U. mine* (Joseph McConnell) lies nearly opposite Fort Pitt on the south side of the creek and at 915′ A. T.

No information could be obtained here. The tipple is immediately on the railroad; but the pit mouth lies to the east around the hill and nearly 90′ above the track.

The reported output in 1885 was 25,992 tons.

A little above Walker's Mills Sta. (833′ A. T.) is the *Ewing mine* (Ewing & Gordon), on the south side of Robinson's creek and at 940′ A. T. This mine was also idle; the dip is decidedly south-east and south-west, compelling pumping.

The hill cover is considerable, and the returned totals of output here reached 20,000 tons.

A massive sandstone, somewhat flaggy on top, crops all along the railroad here, first assuming massive proportions at Fort Pitt, and continuing westward 75′± thick to a point midway between Walker's and Hay's stations. The Ewing mine tipple posts are built upon it, and it is very extensively quarried at numerous places, though at the top showing a micaceous flaggy stone, irregularly bedded and apt to weather. The lower portion is more massive, and is a fine building stone with a blue-gray color.

It may probably be the Morgantown sandstone locally enlarged.

The coal at the pit mouth of the Ewing mine, measured:

Breast coal, 2′ 8″; Bearing-in, 3″; Brick, 8″; Lower bottom, 1′.

The *Hawk's Nest mine* is a small operation, lying somewhat further west along the south side of stream and the *Cherry mine* (Morris McCue) is the last in this township.

This mine is just at Hay's Sta. (873′) and is approached by a long incline to the pit mouth at 1015′ A. T.

The pit mouth is by barometer, 142 feet above the railroad.

The front coal has comparatively little cover; but the present workings are far back in the hill towards Campbell creek.

The mine was not in a very good condition, and a very limited amount of coal was run out here. There is a steady rise along the main (face) entry here, N. 20° W. for at least 600 yards, somewhat greater at the pit mouth than in 400 yards.

The butt entries driven at right angles to this, N. 60° E. and S. 60° W. are practically level; but drain to the main entry.

At the pit mouth the lower division showed 2′ 8″ of breast coal; 3″ bearing-in and 10″ of brick. The mining coal is claimed to vary from 4 to 6 feet in thickness inside the mine, and 17,511 tons were mined here for the year ending Dec. 31, '85.

The Barren Measure red rocks show along the track at Hay's Sta.

On road leading over to Thom's run, the Pittsburgh coal shows at 1025′ A. T., the country rising about 50′ higher to the south.

Along Thom's run, on the south side of the township, the developments are considerable. These show universally a south-east dip in the coal into the Mansfield synclinal.

The coal first crops on the run at *Linn and Cooper's mine* about 2 miles from Chartiers creek, at about 1015′ A. T.

Linn and Cooper and Sandford No. 2 are the only openings on the north, or Collier Twp. side of the stream. The latter is at 983′ A. T. The average section at both mines shows breast coal 3′; bearing-in, 3″; brick coal, 7″–9″; lower bottom, 1′. The brick coal falls into slack, so that most of the lump comes from the breast, small lumps and quite bright, brittle coal. The dip down creek is about 90′ per mile. The coal facing Chartiers creek is about 825′ A. T.

South Fayette township extends from Thom's run south to the Washington Co. line, with Robinson run for a west boundary and Chartiers creek on the east. Formerly that portion of Collier township south of Robinson run and the Panhandle R. R. was incorporated in South Fayette.

This township is almost entirely underlaid by the Pittsburgh coal, except along the main streams of the township, which have cut down into the Barren Measures. Owing to the universal north-west rise of all the measures from the Mansfield synclinal (which passes through the south-east corner of the township) the greatest thickness of the Barren Measures are exposed along Robinson run, where the Pittsburgh coal is from 1030′–1050′ A. T. and from 100′ to 125′ above the creek.

Along Thom's run, all the developments in this township are on lands leased from the Chartiers Block Coal Co.

This tract comprises about 1,400 acres of high grade gas coal, bright, clean and of regular thickness.

Up to date the workings of the various mines are not very extensive ; but development has gone far enough to demonstrate that in addition to a south-east dip to the synclinal, all the coal sinks steadily south-west too.

The tract has a considerable frontage along Thom's run, but not much depth, and it is quite possible that the various operations can be successfully drained out to the stream. At the same time the natural drainage is to Miller's creek and a gangway run along the rear property line of this tract and extended south-east to Miller's creek, would relieve this entire coal field of much annoyance from water and allow of a more systematic method of development.

By an extension of either the Chartiers Valley or the Pittsburgh, Chartiers and Youghiogheny railroad up Millers run, a magnificent field of excellent coal could be readily developed here, and mining could be carried on at a minimum cost. Indeed were it not for the fact that trade follows railroad development, all of the extensive mines along the Panhandle railroad should have been properly located on Millers run, and the drainage of many of them could be greatly improved to-day by taking advantage of natural conditions inviting the attention of almost every operator there.

It has been already stated that the coal first appears on Thom's run at about 1015′ A. T. near Beachmont Sta. on the P. C. & Y. R. R.

The first operation on the Chartiers Block Coal Co's. land is the *Federal Spring mine* (W. J. Steen) at Ramsey Sta. This is about 300 yards down run from Linn and Cooper's, and the coal has fallen 15 feet to 1000′ A. T.

The breast coal here is also quite brittle and breaks out in small lumps; but very clean and firm.

The main entry is on the butt cleavage, S. 65° E. The coal along the gangway rises for the first 550′ to a hummock, falls to a clay vein 3′ per 100′ for 250′ and then rises towards rear boundary. In 500′ a water-course, irregular entry, takes the water out to a point on the creek below the pit mouth. All the rooms up from main entry (west) drain out to creek further up ravine. All single entry. The clay vein courses along main entry 800′ from pit mouth, and bears generally south-east. A second one crosses this one in the left hand rooms, and bears nearly parallel to main entry. A small swamp has been met with here. The output in 1885 reached 11,294 tons.

The following section was measured in Room No. 11 near a small horseback:

	Sandstone,			
	Coal,		8″	
	Slate,		3′	
	Coal,		5″–7″	
Lower division,	Main clay parting,	1′	0″	
	Breast *coal,*	2′	9″	4 6″
	Bearing in *coal,*		3″	
	Brick *coal,*		10″	
	Lower Bottom *coal,*		8″	
	Limestone floor,			

The outcrop heads up a small ravine just below this mine returning again to the road just back of the store, and is opened alongside the road here at *Keasleys pit* 976′ A. T. immediately opposite the new Sandford mine.

The operation is a small one, working in a few acres of coal not held by the Chartiers Block Coal Co. The plant is poor.

Thoms run or *Chartiers and Cleveland* (Harper's) *mine* is the next opening along the creek, just above water level, and close to where the public road crosses to the north side of the creek The coal has to be lifted here from the pit mouth to the tipple in order to give room for loading into cars. The pit mouth is 938′ A. T. This coal was in dispute, and the mine idle, although 20,506 tons were mined here in 1885.

Smith mine (Power's) is about ¾ miles down stream at 886′ A. T. They mine in about 400 acres leased from Chartiers Co. In order to get tipple room, the coal here (cropping close to creek level) is reached by a slope, the above elevation being that of the coal. The main entry is driven quartered, and about on the line between Powers and Hazleton leases. The water course is driven parellel to the main entry and drains out below the tipple. The main entry was driven back about 500 yards and in a nearly north and south course. The mine is quite regular and is very little troubled with swamps. The average run is about 200 tons a day of which perhaps 33 per cent. is lump. The total production in 1885 was 34,000 tons. The butt entries, driven up creek, rise rapidly, and are all quite regular. The coal section shows little or no variation from the Federal Spring mine.

The *Pioneer mine* (Hazleton & Co.) is about ½ mile still further down creek; also opened by a slope. Coal level here 870′ A. T. The coal is about 10′ above creek level here and practically similar to the other openings mentioned. The output in 1885 was 13,950 tons.

The dip now becomes very much more gentle as the synclinal is approached, the next mile showing only about 30′ of a fall to the Coulter country pit at 825′ A. T., just above the mouth of Thoms run and alongside the public road.

Bridgeville Sta. on the Chartiers Valley R. R. is 822′.

Along the Panhandle railroad the openings are numerous.

The *Oak Ridge mine* just below the station of that name, is the first development seen going west from Greggs Sta.

The incline passes up from a siding, under the public road, to the check house, from where a short surface road reaches the pit mouth on the hillside at 1035′ A. T. or 130′ above the track. The present openings are in the second hill, reached by a tunnel 1550′ long through the first hill, and a trestle 400′ across ravine to second pit mouth. From this latter point the coal falls 21′ to the property line, and keeps dipping steadily south-east. The new workings adjoin those of the National on the south-west. A swamp runs south-east through the second hill, east of the main entry, necessitating pumping for all that portion of the mine. The coal along line of swamp is about 5′ thick. A section taken in No. 1 entry near main entry shows:—

Roof coal, bottom member,		9½″
Main clay parting,		7½″
Breast coal,	2′	6½″
Bearing in coal,		3½″
Brick coal,		10″
Lower bottom coal,	1′ to 1′	2″

The average thickness of merchantable coal is 3′ 4″, the mine furnishing about 110,000 bushels per month to the railroad trade. The total output in 1885 was 30,400 tons. The mine is opened entirely on single entry. The coal is good throughout.

There is quite a ravine immediately south of Oakdale Sta., which, with its branches, has cut out the coal considerably.

Near the school house, on the Thoms run road, the coal crops at 1030′ A. T.

The *National Coal Works* are situated further west, and about 250 yards below Noblestown station. The pit mouth is at 1050′ A. T., Noblestown being 926′ A. T.

These mines have likewise been extended into the third hill, where the present work is being carried on, the main entry following quite an irregular course and finally leading over towards the Oakdale mines. It is probably 1½ miles long. The coal all dips south-east, and the total mined in 1885 was 17,959 tons.

The roof coal is in places 7′ thick, with partings; the lower division differs but slightly from that given at Oak Ridge.

There is quite an extensive wire rope haulage here for over a mile inside the pit. The cars are lowered from the check house by a rope and drum, without steam power. Single entry is adopted throughout the mine. Considerable water collects, owing to the south-east dip, most of which must be pumped from the mine, from a point in the third hill and close to the Oak Ridge line.

The *Mankadick mine* is located about 400 yards below Willow Grove station, in a bluff at about 1045′ A. T. The coal here is pretty well worked out; dip south-east.

The *Willow Grove mines* (T. B. Robins), just above the station, are among the most extensive in the district. There are really two distinct mines here, the new workings lying to the south-east in the neighborhood of Robinson Run church; and the old workings still further east.

The front coal is about 1040′ A. T., the main entry going in on true butt and dipping for 1600′+ to a swamp. The coal rises slightly and temporarily still further south. A swamp entry connects the old workings at this point by which the water is collected on the main entry and pumped from there out to main pit mouth. In this mine, especially in the new pit, the miners bear-in on the bottom limestone, or within 2″ of it, thus obtaining from 4′–6′ of coal. The breast varies from 3′ to 4′ thick.

The old mine, to the west, extends to the Mankadick workings, and is all single entry. The new entry is being driven double from beyond the church reservation, and a connection has been made between the two mines. Everything north of the main face connecting entry dips N. W., so that that entry probably marks a line of swamp or a shallow synclinal fold in the coal. All the west entries in the old works drain south-west. But in the new pit the coal dips fully 15′–18′ into the swamp from the outcrop. The output averages 300–400 tons a day, all mined by mule power; total in 1885, 51,000 tons.

West of these works the crop extends a considerable distance up a ravine where it is again opened, close to the

Washington line at the *Laurel Hill mines* (W. P. Rend & Co.) probably the most extensive mines along the Panhandle railroad.

The pit mouth is a couple of hundred yards back from the railroad in the hollow and at 1045′ A. T. The main entry extends south-east, quartering the coal for 2400′, then turning on true butts for 700′, and then about 1600′ further on a course a little south of butts. It is driven double, and the entire mine is worked upon this system.

The end of the present main entry is only about 4′ lower than the pit mouth; but the entry rises and falls between, the coal really dipping south-east in this part of the field. The irregularity of dip may be somewhat influenced by the proximity of the Claysville anticlinal, which touches the railroad near the mine; but there is absolutely no drainage to this immediate coal area at all.

A considerable portion of the water is collected in the main entry about 500′ from where it turns off true butt, and is drained from there by a pipe leading to No. 1 pump. The latter is situated on a butt entry leading off the main gangway near the pit mouth, and about 800′ from the entrance. The coal is here 12′ lower than at the pit mouth or 1033′ A. T. The butt entry is carried back some 2100 feet; but all this western portion of the property is pretty well worked out.

No. 3 pump is situated here towards the extreme west boundary, and the coal in a swamp there is 17′–20′ lower than at the pit mouth.

No. 2 pump throws water out of a shaft, located in the eastern part of the workings, and on a butt entry about 650′ in (south) of second face entry. The drainage can not be well described without a diagram of mine workings, and it is to be greatly regretted that it was impossible to make provision for the collection of much valuable data of this sort, kindly placed at the disposal of the Survey. It is only by patiently plotting such material upon a uniform scale and on one general map, that the true significance of the many local dips, swamps and irregularities of the bed affecting the entire region, will be correctly understood.

And of course it would be idle to attempt this before obtaining a good base-map upon which to put this underground material. The butt entries in the Laurel mine are driven about 180 yards apart, from centre to centre.

The wire rope system is extended to three separate parts of the mine. One bull wheel is in main entry, near left face entry, 3700′ from pit mouth; another at end of fourth butt 1100′ from main entry and the third road passes to No. 3 pump.

This system is illustrated and described by Mr. Taylor in Chap. X.

The ventilating fan is located right above the pit mouth and furnishes about 18,000 feet of air a minute, which is subdivided by the usual means, for different parts of the mine.

There are 24 Harrison coal cutters in use here (also illustrated in Chap. X.) all run by compressed air, which also assists in ventilation. The Allison air-compressor is used here and is quite effective. It furnishes air at from 60 to 70 lbs. pressure, the loss at the face workings averaging about 10 lbs.

The average run is about 17,000 tons of lump coal a month in addition to which there is 5,000 to 6,000 tons of nut and slack, nearly all of which is utilized in the 31 coke ovens.

The total output in '85 reached 259,476 tons.

The coal section as measured at mouth of Brown entry, 50 yards from pit mouth, shows a block coal as follows:

Roof coal.		
Slate,		3″
Coal,	1′	2″
Main clay parting,		7″
Lower division, (block coal,)	4′	6″

The main coal varies from 4′ 6″ to 6′ 3″, averaging a little over 5 feet. Bearing-in is done on the limestone, using largely machine cutters. The front coal is all block; all members are equally good and the bearing-in slates thin and insignificant.

Further in the hill, where the block coal changes to bench coal, the breast and bearing-in coal furnish about 4′ and the bottom coal 1′ 2″ to 1′ 6″. Here too "black jack" or "nigger head" becomes a troublesome impurity in the coal. This coal should naturally be drained out to the Mohawk school house, on Fishing run branch of Miller's creek, where the coal is about at 960′ A. T. As it is, three pumps are required to keep the mine dry.

Miller's creek enters Chartiers near Bridgeville, where the Pittsburgh bed is just above water level at the first bridge crossing on road leading up the stream.

Owing to the south south-west course of the stream, and its gentle fall, the coal is barely under water level all the way to the Washington line. But any westward turn of the stream exposes the coal, while the branch streams entering from the north-west show the coal more extensively owing to the rise of the measures in that direction out of the Mansfield synclinal.

Thus from a little above Wm. Carlisle's place, on Miller's run, almost to Mr. Collins', the bed shows on both sides of the creek at from 825′ to 835′ A. T.

On Jackson's run the coal rises to daylight about half a mile from Miller's creek, above Mr. J. Stewart's house, and outcrops for more than a mile up stream to Campbell's at 969′ A. T.

Hopper's bank, a little below, shows the coal at 964′ A. T.

The coal section is quite similar all along here and shows about as follows:

Roof division,	6′	12′ 6″
Main clay parting,	1′	
Lower division,	5′ 6″	

The roof coal shows two benches separated by 30″ of clay.

On Fishing creek, the coal is exposed from Miller's creek for a mile and a half to the Mohawk school house.

At *Dinsmore's opening*, at the mouth of the creek, the coal is at 880′ A. T.

The coal here shows but a very small parting between the roof and bottom coal as follows: Roof division, 4′ 8″; main clay, 3″; lower division, 5 feet. There is quite a heavy bed of bituminous shale resting on top of the bed. The roof coal has two main benches. The coal is rising rapidly north-west to 927′ A. T. at Wallace's and 955′ at Campbell's pit, finally going under cover below the school house at about 960′–970′ A. T.

This is an excellent field of undeveloped coal, and from its superior position and availability, must soon command attention. A great deal of the coal, like that along the Panhandle, is of a block nature, the whole lower division being without partings or benches. While of course development has proved, in the larger mines of the township, that the character of the coal is very liable to change into the characteristic "bench" form of the Pittsburgh bed, the coal, when so changed, is quite as valuable though a more common commodity.

The outcrop of the Pittsburgh coal extends south-east up Chartiers creek, past the railroad bridge nearly to the mouth of Coal run, where it disappears, on the east side of the synclinal, at about 820′ A. T.

The south-west slope of the measures carries this bed still deeper along Coal run; but on Chartiers creek, owing to its south course, gradually approaching the Washington anticlinal, the coal is struck at 817′ A. T., at the *Hastings mine*, close to Hastings station on the Chartiers Valley railroad.

This mine has been quite extensively worked in the past, producing 43,000 tons for the year ending October 31, 1884, and 30,000 tons in 1885. The coal is reached by a slope 125′ long and 33 feet deep heading N. 88° 30′ W. from the bottom of which a face entry is driven N. 35° E. for 450′ in which the coal is nearly level, dipping first about 15″ to the furnace (200′ ±) and then raising 15″ to the butt entry. But the usual and final dip in the rear workings is to the north-west, towards the synclinal and Coal run, while the south side face entries drain south-west.

The coal section shows roof division 5′ 4″; clay parting 6″; lower division 5′ 10″. The lower bottom averages about 1′ 4″ and is not mined. The balance 4′ 6″ is most excellent coal. Passing Hastings station, and the anticlinal, the dip along the creek is south-east all the way to the Washington line.

The following vertical section was compiled south from Hastings Sta. (K. p. 317).

1.	Concealed,	70′	0″
2.	Limestone,	2′	6″
3.	Clay shale,	4′	0″
4.	Sandstone,	5′	0″
5.	Concealed,	25′	0″
6.	Sandstone,	5′	0″
7.	Concealed,	10′	0″
8.	Limestone,	40′	0″
9.	Clay shale,	1′	0″
10.	*Bituminous shale*,	1′	6″
11.	Shale and sandstone,	30′	0″
12.	*Bituminous shale*,	1′	0″
13.	Limestone and shale,	7′	0″
14.	Dark shale,	2′	0″
15.	Limestone and shale,	12′	0″
16.	Shales,	50′	0″
17.	*Pittsburgh Coal Bed*,	11′	8″

No. 8 is largely a solid limestone, representing the bottom number of the Great Limestone, and outcrops along the railroad for some distance.

Chartiers township is a very irregularly shaped area, facing the Ohio river at Brunot's island, bounded on the north and west by Chartiers creek, and with Union township and the city of Pittsburgh, making an irregular border line on the east. All the coal in the township lies east of the Panhandle railroad; which after leaving Nimick station, curves south-westward through the Cork Run tunnel and passes nearly through the centre of the township to Chartiers creek, at North Mansfield. The *Brady's Bend anticlinal* is continuous from the mouth of Woods run across to Sheridan station, but is dying rapidly south-west, and disappearing in the hill east of Crafton.

The Chartier's creek approximately marks the *Mansfield synclinal.* Its valley is greatly eroded, so that in all the western portion of the township, the upper rocks have all been removed and only imperfect exposures of the Barren Measures occur. The Crinoidal limestone and coal are well exposed along the Panhandle railroad, rising northwest about with the railroad grade from Temperanceville to Sheridan station, the total rise between these points being about

80′ and the distance about 1½ miles. Just at Sheridan the rocks are eroded along the crest of the anticlinal by a ravine; but between the station and the tunnel entrance the limestone and coal come in again on a steep northwest dip, passing under the track between the station and the tunnel at about 860′ A. T.

The following section of the Barren Measures was made in the tunnel approach cut. (See report K, p. 312.)

1.	Concealed,	60′	0″
2.	Limestone,	Fragments.	
3.	Concealed	125′	
4.	Laminated shale,	30′	
5.	*Coal,*	0′	4″
6.	Variegated clay,	12′	
7.	Limestone,	1′	5″
8.	Variegated clay,	10	
9.	Sandy shale,	35′	
10.	Clay shale, with nodular limestone,	12′	
11.	Sandy shale,	6′	
12.	Dark shale,	20′	
13.	Crinoidal limestone and shale,	5′	1″
14.	*Coal,*	1′	
15.	Shale to track,	5′	

"The *Pittsburgh coal* occurs near by, and is two hundred and sixty feet above the track at the south end of the tunnel, where No. 9 of the section is the lowest rock seen. The Crinoidal limestone has the following structure here:

"Ferruginous limestone, 17 inches; sandy shale, 15 inches; red limestone, 14 inches; black calcareous shale, 15 inches; total, 5 feet 1 inch.

"It is, however, very irregular, for at one spot in the northern approach to the tunnel, it is a mass of nodular limestone nearly eight feet thick. Each of the limestone layers contains many fossils, and the black shale at the base is very rich in individuals of a few species. The underlying coal is rather more sulphurous than it is along the river. Nos. 4, 9 and 12 of the section show marked fissures, all of them nearly vertical and filled with vertically laminated shale.

"Of the section, all the strata below No. 9 pass under the track in the tunnel, and at Ingram station, at the end of the southern approach, only ten feet of that rock are in sight.

The little coal, No. 5, goes under the track about midway between Ingram and Crafton.

From Idlewood station to Mansfield the railroad and the rock measures descend at about an equal rate, and in the several cuts between these points the upper portion of the above section, down to No. 6, is frequently exposed.

At Sheridan station, the Pittsburgh coal is over 1,100′ A. T. in the hill south-east of the railroad.

Almost all the coal occurring in this township has been worked out through one or the other operations penetrating it from the east or originally mining within its limits.

On the road leading from Ingram station over to McCartney's run, the coal is opened well up toward the hill-top at *Hodgson's*, 1080′ A. T.; here dipping westward. Crossing the hill and anticlinal it shows in *Wellengills* and *Gormley's* abandoned pit, at 1088′ A. T., now dipping south-east, down the run, and opened within the present city limits, at the *Wood's and McClay* pit, near the plank road, at 1060′ A. T.; the *Carlin pit* 200 yards further down the run, at 1070′ A. T.; and between these two, at the old *Fox pit*, at 1065′ A. T. The pillars were being robbed at this old opening. The main entry goes in on butts and dips south-east for 125 yards, and then rises in the same direction for 175 yards, being no doubt influenced by the Washington axis to the south-east.

All the south face entries drain to the south-west.

The following section shows at the mouth of Fox's pit:

Sandstone,		
Coal and slate,	1′	4″
Carbonaceous shale,	1′	6″
Coal,	1′	8″
Slate,		2″
Coal,		8′
Main clay parting,	1′	0″
Breast *coal*,	3′	
Bearing-in coal,	0′	4″
Brick coal,		10″
Lower Bottom,	1′	4″

All this coal here is drained south-west to the head of Dinsmore's hollow, where the *Carlin rear pit* shows at 980′ A. T., on the north side of stream, and at *Lewis' pit* (draining Fox Mine) on the north side of run, at forks of road, at 976′ A. T. These openings are at the head of the outcrop on this run. But going down stream, nearly due west, there are several country pits all showing a dip into the Mansfield synclinal, past the line of the Brady's Bend axis.

Thus in order come Foster pit, 950′ A. T.; Handenschield's pit, 950′ A. T.; Woods pit, 945′; Woods lower pit, 940′.

The Foster (old Frew pit) and Handenschield pit were the only active ones, furnishing a small amount of coal for country use. In each the following section of the lower division shows :

Main clay,		10″
Breast *coal*,	3′	6″
Bearing-in *coal*,		3″
Brick *coal*,	1′	3″ to 1′

The lowest part of the bottom coal is not taken up, the above showing the mining coal, with a portion of the bottom classed as brick coal. This pit drains south-west to Whiskey run, where the coal on the left fork, along the township line, is at 900′ A. T. in Holme's pit.

The *Phœnix mine*, on the Panhandle R. R. at Idlewood station, is the only large operation in the township, and it is nearly worked out and in very bad shape. The elevation of pit mouth is at 957′ A. T., showing a little rise from the Woods pit, in the rear hill. The main entry is quartered, and evidently rises somewhat south-east, for an old abandoned opening immediately back of the mine shows an elevation of 970′ A. T.; while the Dinsmore pit, across the ravine, is 975′ A. T. These two openings *may* be on the point of the expiring Brady's Bend axis. The following section showed at the pit mouth :

Coal,	1′	
Slate,		4″–8″
Coal,		10″
Main clay slate,		9″
Breast *coal*,	3′	4″
Bearing-in *coal*,		4″
Brick and bottom exposed,	1′	8″

Not all of the roof division is exposed—output, 11,226 tons.

Lower St. Clair, Union, and City of Pittsburgh, south of the river.

It is not possible to treat separately these three districts, owing to the irregularity of the city boundaries south of the river. Geologically they contain nearly the same rocks, except that along the Scott Twp. line the Pittsburgh coal is under water level and covered by 300′–350′ of the Upper Productive measures; where as along the river front, the same coal is in the hill tops, with comparatively light cover, and with about the same thickness of the Barren Measure rocks between it and the river.

Lower St. Clair township adjoins Baldwin on the east and extends irregularly back from the river to and beyond the Pittsburgh and Castle Shannon railroad. *Union Twp.*, with the boroughs of Espy and Greentree, has Chartiers and Scott on the west and south, and the city on the north and east.

Beck's run is the dividing line between Lower St. Clair and Baldwin, for some distance from the river, and at its mouth it has cut down about 250′ into the Barren Measures, while its general erosion has spread the outcrops of the Pittsburgh coal bed on either side of it $\frac{3}{4}$ miles apart.

Near Ormsby Sta., on the Monongahela Division of the P. R. R., the coal was opened at the *American mine* (Jones & Laughlin,) a mile from the river at 1,035′± A. T. It was opened in 1854 for the use of the American Iron and Steel Works, but was idle when visited by reason of the introduction of natural gas into these works, and only 26,407 tons were mined in 1885.

The mine was a very extensive one, the workings having been extended over 4 miles from the front pit mouth S. S. E. into Baldwin Twp.

The coal of the *Birmingham Coal Co.* (Keeling & Co.,) has likewise been largely mined from Lower St. Clair township.

The *Ormsby mine*, located at 21st St., South Pittsburgh, at 1,020′ A. T. and the *Bausman mine*, of the same company at 12th St., 1,020′ A. T. have both been large producers in the past. They have both been extended through the front hills and far into Baldwin Twp. The workings of one mine coalesce with those of the other, and it is hardly possible to describe them in detail. A stationary engine hauls the coal from Spiketown to the river trade, and another engine at Spiketown attends to the workings in the rear hills, probably 4,000 yards from the rear pit mouth. The river tipple is arranged for lowering the cars bodily to the boats. The two mines connect at Spiketown. From this point the coal intended for the city trade is hauled through the Bausman tunnel to the front pit mouth by a locomotive, and from this point the cars are distributed by the one stationary engine and road to different parts of the rear hills.

The water collects mainly in the west part of the Bausman workings, and is pumped through a shaft 100′ deep. The coal is everywhere quite regular and but little trouble except for the fact of the drainage following the south-westward extension of the workings in Baldwin Twp. Very little coal was run from here during 1885 owing to the general adoption of natural gas at places these mines supplied.

There is probably 160′ of cover to the coal, along the river hill here, the coal dipping south-east into the Nineveh synclinal.

The entire coal bed is here about 11′ thick, of which the lower division contains about 5′ 10″ of coal, the main clay 10″ and roof coal about 5′.

The Ormsby mine produced 126,433 tons in 1885, in which is probably included the product of the Bausman mine.

From these mines the measures are slowly rising northwest to an elevation of about 1040′ A. T. along the river bluff to Temperanceville and Saw Mill run. Here in South Pittsburgh or Mt. Washington, the Castle-Shannon mines were originally opened, the old main entry now being used for the tunnel of the Pittsburgh & Castle-Shannon R. R. Only pillar-coal is left in Mt. Washington now, the mines of the company lying further south along Saw Mill run.

Saw Mill run is a short but important tributary of the Ohio river, entering at Temperanceville. Its main branch heads near Castle-Shannon and is the avenue for travel selected by the Pittsburgh & Castle-Shannon R. R. The west branch leaves the main stream about 1½ miles from the river and heads up towards Mt. Lebanon in Scott Twp., and is occupied as far as Banksville by the Little Saw Mill run railroad.

Both streams have been powerful factors in the erosion of this part of the country, further augmented by the presence of the Washington anticlinal which passes between them. Both have worn down deep channels, exposing nearly precipitous walls of the Barren Measure rocks back of Mt. Washington and as far south as Banksville, Fairhaven and West Liberty borough.

Excellent exposures of the Morgantown sandstone, Birmingham shale and the Barren Measure reds can be seen in any of the branches.

But these streams fall very rapidly, so that when they have cut down the coal measures 350′ at Temperanceville, the Pittsburgh coal is at creek level at Banksville 3 miles from the river by railroad. The coal has dipped southward along the axis about 90′+ in this distance and at the river is 1040′± A. T. so that from Banksville to Temperanceville, the creek falls 250′± or 80′+ per mile.

On the line of Lower St. Clair and Baldwin, along the main stream, the coal is still well up above the creek and the railroad built on high trestles.

The Castle-Shannon mines are located up a branch from the Stone House and are opened at about 975′ A. T. the coal rising northwest to 981′ in West Liberty borough, and northeast to 991′ in the bluff back of Bell House. The larger part of these hills are worked out of available coal, and numerous gob piles along these streams attest the former activity of the region. The horizon of the Great Limestone is frequently met within the hills between the outcrops of the Pittsburgh coal; but with the exception of the region bordering Baldwin and Scott this great calcareous formation can rarely be recognized. It seems to have turned almost entirely into shales. The Pittsburgh (upper) sandstone is likewise thin and disintegrated.

This is equally true of the upper Productive Measures in Union Twp. Here the Pittsburgh coal is dipping everywhere south-west into the Mansfield synclinal. Indeed all of the coal west of the Washington pike drains westward through Whiskey run to Chartiers creek, the coal arching gently over the Washington axis in a broad and nearly level band before dipping southeast toward Fairhaven and Saw Mill run.

Along the river front the natural exposures of the Barren Measures are of course quite persistent; but owing to frequent landslides, and the rapid erosion of the Birmingham shales, they are not so perfect as might be desired. The Crinoidal limestone and its little coal can usually be found here when not artificially covered up, and always about 300′ below the Pittsburgh coal. The following vertical section of this upper half of the Barren Measures well shows the character of these rocks in the vicinity of Pittsburgh. It was taken on the road leading up hill south from Birmingham station on the P. C. & St. L. R. R. (See K. p. 309):

1.	Shale and sandstone, imperfect exposure,	150′	0″
2.	*Pittsburgh Coal bed,*	—	0″
3.	Concealed,	33′	0″
4.	Shale, with iron ore,	28′	0″
5.	Limestone,	1′	4″
6.	Shale,	14	0″
7.	Limestone,	2′	5″
8.	Sandy shale,	27′	0″
9.	Limestone,		10″
10.	Variegated shale,	23′	0″
11.	Calcareous sandstone,	2′	0″
12.	Sandstone,	52′	0″
13.	Variegated shale,	11′	0″
14.	Dark shale,	45′	0″
15.	Dark shale, not bedded,	3′	0″
16.	Limestone,	3′	0″
17.	Shale,	24′	0″
18.	Crinoidal limestone,	1′	0″

The most noticeable feature of the river bluff opposite Pittsburgh is No. 14. It weathers readily and breaks out in large blocks, the cleavage planes being vertical. To its disintegration is due much of the damage frequently caused by landslides letting down the massive sandstone, 50′ thick, above it, besides concealing much of the section beneath it.

The Crinoidal limestone is usually accompanied here by a thin coal occurring just beneath the limestone and from six to eighteen inches thick. The limestone can hardly be mistaken, and is therefore a rather persistent key rock to the measures above and below it. It is here a tough, roughly granular rock, fossiliferous and ferruginous, and with its coal bed extends with little interruption east and west to above Braddocks station and beyond Sheridan station on the Panhandle railroad.

Messrs. Gray and Bell have been large operators in this part of the field in the past, though at present their mines are entirely idle. Their old pit mouth still stands on the high bluff, within the city limits, and close to the (north) Union line at 1000′ A. T. The coal here is fully 250′ above Saw Mill run, which was reached by a long incline, now entirely abandoned. The crop extends west across the pike at 995′ A. T., to Fox's new pit, in the deep ravine below the Presbyterian church and cemetery at 990′ A. T. Southward, the coal crops along Little Saw Mill run, gradually approaching that stream, as the latter rises and the coal falls, until disappearing above Banksville at about 955′ A. T. The crop has been punctured in many places, and most of the available coal north from Greentree borough has been removed.

The present workings enter the hill from below Banksville, the *Venture* and *Chess mines* being connected. From the Banksville opening at 960′ A. T., a butt entry is driven north-west for 4777′ dipping all the way and draining through another entry south-west into the middle fork of Whiskey run at 880′ A. T. At this latter pit mouth the ventilating fan is situated. The old workings in the front hill all drain to this point too. A face entry passes through the first knob into a ravine, and entering the second hill turns more south-west, slightly off face, from which another entry diverges still more south-west and carries the mine drainage directly to Whiskey run. These mines were recently flooded in order to put out a disastrous fire that had taken place in the underground stables, and up to Aug., '86, work had not been resumed in them.

The *Coal Ridge mine*, of the same company, extends into the hill south-east, on the east side of Little Saw Mill run, and back of the borough of Espy. The rise here to the Washington axis is very marked.

The *Enterprise mine* (Hartley and Marshall) enters the crop near where it disappears beneath water level, at Banksville, at 955′ A. T. These works are quite extensive. The main entry is a little off the face and dips ¾± miles to the pump, further up the run towards Mt. Lebanon, where the coal level is 120′ beneath the surface, and about 890′ A. T. The cars are hauled from here by wire rope to the pit mouth. A large part of the drainage, which is generally north-west and south-west, is collected at this point. From here an engine road diverges, off butts, for about 4500′ south-east, rising to 917′ A. T.

All the loaded cars are brought to this point by mule power. This engine entry is extended somewhat further; but the mine maps furnished no scale or exhibition of the working areas, not having been brought up to date. In a day's run here it is estimated that for each 100 bushels of lump coal, there would be 25 of slack and 27 of nut.

The total output for 1885 reached 147,109 tons.

The coal mined here averages about 4′ thick, of which 3′ is breast. It has a high reputation in the trade for cleanliness and gas making qualities, and together with the coal from along the Little Saw Mill run, is deservedly esteemed as among the best fuel sent from the Pittsburgh district. Much of it is shipped in barges to the river trade and much to the western market over the P. & L. E. R. R.

The arch of the Washington anticlinal must be very gentle and broad here, for it was scarcely noticed in the rear workings of the Enterprise mine, though an air shaft on the Knowlson farm, half-a-mile from the axis, finds the coal at 960′ A. T. only 5′ higher than the pit mouth. This shaft is not far from the extreme south corner of the city limits. The cover of Upper Productive Measures is light and generally poorly exposed.

Scott township lies immediately south of the district last described, with Chartiers creek for a western border line, Baldwin township on the east and Upper St. Clair and Snowden lying to the south.

Whether from the amount of coal dug from the western side (the only place the Pittsburgh bed outcrops being along Chartiers creek) or from the amount of coal still remaining untouched, Scott township is to be an important district in the future of the coal trade.

At present the only means of transportation is along the Chartiers Valley railroad, which skirts Chartiers creek from Mansfield to Bower Hill, and the P. C. & Y. R. R. which takes practically the same course, half in Scott, half in Collier.

The Pittsburgh Southern R. R., a narrow gauge extension up Little Saw Mill run, through Banksville and Castle-Shannon to the village of Library in Snowden has been abandoned since the purchase of its charter by the B. & O. R. R., though the Castle-Shannon railroad still has the terminus of its road at the village of that name.

The *Washington anticlinal* cuts the township nearly in half, the smaller area lying to the southeast side of the axis. The *Mansfield synclinal* lies on the west side of the township, and perhaps the western sub-division of the *Nineveh synclinal* barely touches the southeast corner, above Castle-Shannon.

The exposed section extends from 350′ above to 120′ below the Pittsburgh bed; but away from Chartiers creek there are no connected exposures and everything above the great coal bed is largely concealed.

A thin coal bed shows in the cut of the abandoned Pittsburgh Southern railroad, a short distance west of the Washington pike at Mt. Lebanon, close to the anticlinal, and estimated about 275′ above the Pittsburgh coal. It is only 2′ thick, and overlaid with sandy shales. It is possibly the *Uniontown coal bed* and is 1175′ A. T. Mt. Lebanon, at Millholland's store and the Bower Hill road is 1240′ A. T.

What is evidently the same coal crops on the Bower Hill road just near the intersection of the road to Bridgeville at 1125′ A. T. Along the Chartiers creek the openings in the Pittsburgh coal are numerous. On the bluff east of Mansfield, the coal shows facing Whiskey run at *Shawhan's* at 870′ A. T.

Crossing directly over the hill southwest, the coal cropping in the first ravine, is opened on the road in three places @ 860′ A. T.

Geo. Forsythe's opening is the most recent and shows:

Top coal,	?	
Main clay parting,	1′ to 1′ 6″	
Breast *coal,*	3′	
Bearing in *coal,*	0′ 4″ to 0′ 8″	
Brick *coal,*	8″	usually about 2′
Lower Bottom *coal,*	1′ 4″	

The coal is reported to raise on the north face and west butt entries. At the head of the next ravine south from here, the coal is opened at Cook's and Allen's country pits, the latter just where the coal takes cover at 830′ A. T.

Southwest from here, but still on the east side of the road leading over the tunnel, the coal is again opened at the *Mansfield No. 2 mine* at 815′ A. T. This mine is approached by a siding from the Chartiers Valley R. R., and a gentle incline plane from the tipple, crossing the public road to the pit mouth on the hill.

The main entry is driven double 3550′ long on butts S. 64° E., to within 450′ of boundary line (Aug. '86), and now dips all the way to pit mouth. The drainage is a little peculiar here, the main entry having dipped naturally (before being cut down) from the pit mouth south-east into a swamp 3½′ deep before rising again south-eastward. On the *south* side of this entry the face entries drain to the *north-east* and on the north side, *south-west.*

The swamp is quite irregular, meeting the main entry about 1000 feet in from pit mouth, curved thence north-west, crossed the main gangway again in 300 feet and then bore S. 30° E. to the rear property line. Clay veins are frequently met with.

The coal is worked in blocks 750′×450′, with air-courses or "break-throughs." There are two air-shafts and a furnace at head of small ravine 800′ air-line S. S. E. from pit mouth. The average run is about 600 tons a day, all taken out by mule haulage, and the total for the year reached

147,832 tons. The mine lies close to, if not immediately within, the basin.

The coal is not entirely cut off over the tunnel, showing above the arch at about 805′ A. T. and curving north to the *Glendale mine* at 795′ A. T. This pit is immediately opposite the switch of the Mansfield mine, and works a small knob of coal extending west within the great bend at Chartiers creek. The main entry shows a decided northwest rise, and I should judge the coal to lie on the west side of the synclinal. The operation is a small one, producing 20,000 tons in the year 1885. The coal shows the following section: roof division, 1′ 3″; main clay, 1′; lower division, 6′. At the tunnel the following section was taken (K. page 314,) in which the Pittsburgh coal shows single, the roof and clay being absent.

1.	Sandstone, seen,	2′	0″
2.	Sandy shale,	20′	0″
3.	*Pittsburg Coal Bed*,	7′	0″
4.	Clay,	2′	0″
5.	Sandy shale,	10′	0″
6.	Limestone and shale,	8′	0″
7.	Shale and shaly sandstone,	10′	0″
8.	Shale and *Coal*,		6″
9.	Limestone,	3′	0″
10.	Shale,	9′	0″

Returning on the south side of the tunnel, the crop extends about $\frac{3}{4}$ miles up George's creek, or nearly to the Red Store at the cross roads, showing there at 820′ A. T.

The Pittsburgh (upper) sandstone over the coal, is quite largely quarried just at the cross roads, and makes fairly good blue-gray micaceous slabs, though of small size.

A short distance down creek the coal is opened on the south side at *John Drinkall's* pit, dipping strongly southwest and at 815′ A. T., various other old openings showing further down the streams.

The *Nixon mine* is opened right on the railroad, a little south from George's creek, and about 200 yards north of Leasdale at 820′ A. T. They have a double entry here; but no information whatever could be gained concerning either maps or workings. Miners report that the main gangway is nearly level for 300–400 yards, and then rises rapidly south-east. All water drains out of the front pit mouth. About two-thirds of the coal here is worked out, close to the synclinal trough. No tonnage reported here. The *Diamond mine* is still further south, and near Leasdale station. The coal is 30′ above the track and at 824′ A. T.

The main entry 1,200 yards long, is single in the front hill but double in the left hand side. There are several small local swamps, but the dip seems to be *south*-east, the coal at the end of the main entry being 12′ to 15′ lower than the pit mouth. Like all mines close to synclinal troughs, it is considerably troubled with local irregularities indicating some relation between swamps and axial lines. The water here is pumped out of a shaft in the rear workings and drains down the Leasdale road. The bed section is about as the rest through here.

Leasdale mine (Leasdale Coal Co.) is situated on the railroad, just south of the station at 822′ A. T.

This mine was idle when visited, but access was given to the company's map from which the following facts were obtained.

The entire tract consists of about 63 acres, and is laid out on the double entry system. The coal all drains to the north-west and south-west, out the main pit mouth and to Scrubgrass run on the south. The mine is but slightly opened as yet, and the main entry will be about 2000 feet long to the back property line. No output is reported here.

All this coal lies on the east side of the synclinal.

The *Summerhill mine* (Frank Armstrong) is near Woodville Sta. the coal being opened about 20′ above the railroad at 824′ A. T. No information could be gained here, except that all the front coal had been worked out by single entry system, the double entry having been started about 1800′ in from pit mouth.

The coal is worked in blocks averaging 950′ × 450′; the main entry is on butts S. 58° to 68° E., and face entries north all run out to Scrubgrass run. The output for 1885 reached 40,000 tons.

The south boundary of tract is the township road for some distance. Drainage is similar to Leasdale mine.

The average thickness of lower division coal here shows:

Main clay parting,	1′	4′ 11″+.
Breast *coal*,	3′	
Bearing-in *coal*,	0′ 3″	
Brick *coal*,	0′ 8′	
Bottom *coal*,	1′+	

In the railroad cut at Woodville station, the coal is about 16′ feet above track at 820′ and the following section shows:

Sandstone massive,			
Shales and thin sandstone,		12′	
Coal,			4″
Shales,		4′	0″
Sandstone,			10″
Roof division,	*Pittsburgh coal*,	4′+	
Main clay parting,		1′	
Lower division,		5′	1″
Limestone,		1′	
Shales,		0′	10″
Sandstone,			8″
Slaty *coal*,			5″
Limestone,		1′	0″
Calcareous shales,		3′	6″
Sandstone to track level,		4′	

The *Bower Hill mines*, old and new, lie further south along track, and had been idle for some time. The new pit is at 805′ A. T. and the old works, further south-east on switch, 824′ (?) A. T.

Jones county pit is still further south, facing Chartiers creek just at the big bend westward, at 800′ ± A. T. This pit is across the line of Scott Twp. and seems to mark a swamp, as the coal dips to it from all directions. The opening is close to the mouth of Painter run, and the track of the Pittsburgh, Chartiers and Youghiogheny railroad.

The Washington anticlinal lies only about 1½ miles to the south-east of Chartiers creek at this point and lifts the coal to about 895′ A. T. on its crest.

Upper St. Clair township lies immediately south of Scott, and in a measure continues its geological features, until the sinking of the measures south-west buries the Pittsburgh coal a little south of McLaughlin's run and Bridgeville and exposes an enlarged section of the Upper Productive measures along the Washington line, and even reaches to the bottom members of the Upper Barren measures in the extreme south-east corner.

Chartiers creek again forms a western boundary line to the township, which also lies immediately north of Washington Co. and west of Snowden township of Allegheny.

As in Scott, the Upper Productive measures are very unsatisfactorily exposed, and the surface is largely covered with débris, from the decomposition of the Great Limestone, which shows in the eastern portion of the township quite earthy and decomposing readily.

At Sodom this limestone shows in McLaughlin's run; and the same rock, with accompanying measures above and below it, is seen along the Chartiers Valley railroad and creek to and beyond the Washington line from Boyce's station.

The *Washington anticlinal* enters the township on a north branch of Painter's run, crosses the main creek between the Essen and Harrison mines; McLaughlin's run just above McMillan's opening, and Chartiers creek above Hastings station. No coal is exposed east of this axis, the country rising as the coal dips to the south-east.

The dip of the coal north-west into the Mansfield synclinal (which just touches the north-west edge of the township at the big hook in Chartiers creek) is quite gentle, the difference in level being only about 40′ and the distance 2 miles. The outcrop of the Pittsburgh coal enters the township at Jones' pit, near the mouth of Painter's run at 800′± A. T.

The anticlinal to the south-east, together with the erosion of the creek, keeps this bed above water level for 1½ miles on Painter run, up which the P. C. & Y. R. R. has been extended for the development of the coal. Along the creek, the bluffs and railroad cuts all show good exposures of the Pittsburgh (lower) sandstone, which is here quite massive and of fine texture and color. At the west end of the railroad tunnel (which is driven entirely through coal) the Pittsburgh bed is at 865′ A. T., and the bed rises through tunnel (half face, half end) to 870′ A. T. In the tunnel, an excellent section of the bed shows as follows, 15′ above creek level:

	Roof sandstone.			
Roof division,	*Coal* with thin bands of slate,	1′	4″	9′ 2½″
	Slate,		3″	
	Coal,		7″	
	Slate,		5″	
	Coal,		4″	
	Slate,		3″	
	Coal with thin slates,		7″	
	Main clay parting,	1′	0″	
Lower division,	Breast *coal*,	2′	8″	
	Slate,		¼″	
	Bearing-in *coal*,		3″	
	Slate,			
	Brick and lower bottom *coal*,	1′	6″	
	Limestone.			

The coal crops in the several cuts going up stream to the *Essen mine* (Sandford & Co.), which is almost at creek level and close to the anticlinal. The coal here is 887′ A. T. The mines were quite active, and some excellent coal was being run out, and hoisted for tippling; but no one in authority could be found, and very little information was obtained. The coal is lying apparently quite level here, and it would be interesting to know how the proximity of the axis affected drainage and swamps. The axis is quite plainly marked about 200 yards above the Essen works, and is close to where the coal disappears beneath water level.

The output in 1885 here reached 70,399 tons.

Harrison mine (Beadling Bros.), is on the south side of the creek a short distance further up. The coal here is entirely under water level, being reached by a slope, 31′ vertically to coal, which is about 890′ A. T.

The main gangway is driven about quarter, eastward. It is 1,400 feet long, and with local rolls, dips all the way to 875′ A. T. The first butt entry is about 300 yards long, S. 66° E. to property line and dips all the way to 880′ A. T. The output here is about 200 tons a day, about one half lump, every 25 bushels yielding about 6 bushels of nut and 7 bushels of slack. The coal section (lower division) shows: Breast coal, 2′ 6″; bearing-in, 2″; brick, 8″; lower bottom, 10″. The ridge road from here over to McLaughlin's run rises to about 1120′ A. T., and descending the south side shows limestone at 1010′ A. T. and 960′ A. T.

The Pittsburgh coal is just at water level on McLaughlin's run at Andrew McMillan's at 860′ A. T. Here the coal shows roof division 3′ 6″; main clay parting 10″; lower division 5′ 6″; total thickness 9′ 10″.

The Washington axis must pass near this and *Evans pit* (860′ A. T.) which is about 100 yards down creek. At both places the coal is covered with a rich bituminous shale. The lower bottom coal is about 1 foot thick and worthless, but the upper coal looks very well.

Crowleys pit is about 100 yards below Evans' at 850′ A. T., and only 6 feet above creek level. Here there is a splendid exposure of the entire bed and roof members, washed bare by the creek, with a section quite similar to that taken at the tunnel on Painter run. In places, however, it is irregular, especially in the roof members, where the main clay parting swells to 3′ thick. The bituminous shale on top is quite distinct here. Further down creek the outcrop is opened in various places for the next half mile, where the coal is at creek level at 825′ A. T.

Gilmores pit 825′ A. T.; *Cooks pit* 830′ A. T.; and *Gilmores lower pit* 837′ A. T., are opened successively, in approaching Bridgeville, showing a slight rise of the coal to its outcrop along the Chartiers Valley railroad.

None of these pits were in working order when visited; but the coal showed in them about 5′ 6″ to 5′ 10″ thick, the main clay parting above 7″ to 1′ thick and the roof in one place 3′ 10″.

The following remarks about this coal are taken from Rep. K., p. 316, and are of interest as bearing upon the still obscure cause and effect of clay veins:

"In these openings the coal is good, except in the 'lower bottom,' which is too poor to pay for working. In the upper bench, the top fifteen inches contains binders of sulphur, one of which, at ten inches from the clay, is occasionally strong enough to hold up the coal above. In this bench there are several layers of cannel, and as a whole the coal is rather open-burning. In the lower pit, extensive clay-veins occur, one of which is seven feet wide. Many of the larger ones have a north-east and south-west trend, but there are many others which have a different course. Those following the north-east and south-west direction seem to affect the coal, which is somewhat distorted on each side, while the others appear to have exerted no influence upon the structure.

About one hundred yards above the station the coal comes down to the track and is finely exposed in a cut for several hundred feet. The variations in the roof division are well shown here, as appears from the following measurements:

1. *Bituminous shale,*	8″	10″			
2. Clay,	6″	5″			
3. *Coal,*	10″	1′			
4. Clay,	3″	25″	14″	20″	18″
5. *Coal,*	10″	10″	10″	8″	8″
6. Clay,	25″	2″	½″	9″	2″
7. *Coal,*	18″	10″	10″	11″	9″
8. Main clay parting,	12″	10″	14″	6″	10′
Total, less No. 8,	80″	63″	34½″	48″	37″

Just north of Bridgeville station the coal is opened on the railroad at the *Bridgeville mine* (A. J. Schulte & Co.) at about 832′ A. T. The main gangway S 44° E. is started on top of the coal and raises for 950′ to the rear crop line at about 845′ A. T.

A prominent soot vein bears through the mine from the pit mouth north-east through the point of the hill to Painter creek, opposite Jones pit. A clay vein accompanies it, raising the coal about 4′ east and west. There are several other such streaks in the mine, not yet definitely located, rendering the coal near them quite unsalable.

The output here in 1885, was 39,000 tons.

The front coal here is about 1′ thicker than that back in the hill along the township road; but an average section shows:

Part of roof coal,	*Coal,*		5½″
	Slate,		3½″
	Coal,		10″
	Main clay parting,		10″
Lower division,	Breast *coal,*	3′	2″
	Bearing-in *coal,*		3′–5″
	Brick coal,		9″
	Lower bottom *coal,*		10″ to 1′

The natural north-east rise of the coal is interrupted by a "swamp." The crop is cut out along the railroad, but taken in again on the west side, and occupies a strip of country encircled on three sides by Chartiers creek.

Jas. Frain's pit in the outcrop, shows at 825′ A. T. where the coal shows about the same as Bridgeville Mine.

Baldwin township has a narrow frontage along the Monongahela river, between Becks run and Streets run, with Mifflin and a part of Jefferson on the east, Snowden on the south, and Scott and Lower St. Clair west of it. Though the outcrop of the Pittsburgh coal is confined entirely to the northern half of the township, a very large tonnage has been carried from within its limits. The section of exposed rocks comprises intervals of 350′ above and below the Pittsburgh coal, though those above it are unsatisfactory here, as elsewhere in the neighboring townships.

The *Nineveh synclinal*, though obscure, must pass nearly through the center of the township from Blossomville on the river, practically through the Point View hotel on the Brownsville road and thence on to Snowden township, its trough line being indented by a small anticlinal axis, which reverses the coal dip however, and divides the basin into two parts, along Becks run and Streets run. Beck's station on the P. V. and C. R. R. is at 760′ A. T., and shows the Barren Measure red shales in the hill side.

From here a coal railroad diverges up Becks run for 1¼ miles on a grade of 25″, to the foot of the plane of the *Becks Run mine* (Hays Est.) The check house of these extensive mines is about coal level or 970′ A. T., a short surface road running from here to the front pit mouth at about 978′. All the front coal, on both sides of the ravine, is worked out, the mine road passing through a tunnel, with a fall of 9′ on coal for 650 yards, crossing a ravine 200 yards wide, to the rear pit mouth (double) at about 965′ A. T. A large portion of the mine has been worked by single entry system. The south-east butt entries all drain to the south-east for about 2000 yds from the main entry, before rising towards the Walton line, and are all drained through a "swamp" entry S. S. W. out to a branch of Saw Mill run at 965′ A. T.

The coal here will average, breast 3′ 6″; bearing-in 4″; brick 9″ to 1′; lower bottom 1′ to 1′ 2″.

The output of this mine in 1885 reached 24,000 tons. *Jones and Laughlin* rear workings occupy the area of coal territory adjoining Hays on the west, between Beck's run and Saw Mill run. A large amount of the coal is worked out, and while numerous butt entries drain it to the east and west, a considerable portion is drained also into Saw Mill run at Spiketown.

Here too the *Birmingham Coal Co's* rear workings come to daylight at 960′ A. T. near their mule stable. A trestle is carried across the ravine here and enters the south hill to the east of the old school house. Butt entries of the same company extend south-east from this entry and are carried up to within a short distance of the Point View hotel tract on the Brownsville road.

One of their air shafts is located in the hollow north-west from the hotel and is reported 70′ to the coal at 950′ A. T. which cannot be far off the line of the eastern sub-basin. The Castle Shannon railroad enters the township along the line of Saw Mill run, following the stream to Castle Shannon. The company's mines are located about 3 miles from the river, and operate on the single entry system in that part of the township lying west of Saw Mill run. The pit mouth is 950′± A. T., from where the coal is hauled some distance by mules to the check house and to the railroad tipple. From here the coal is hauled by locomotive to the head of a gravity plain on Mt. Washington facing the river, passing through a tunnel 1740′ long on the coal through *Coal Hill.*

South from here to the mines the railroad is generally below coal level, on the first red band in the Barren Measures. The old openings are numerous along both sides of Saw Mill run, from which thousands of tons of A No. 1 fuel have been taken in the past.

The south-west slope of the measures brings the coal down to 15′ above the railroad at Fairhaven, where it is opened in the *Fairhaven mine* at 939′ A. T. This is a small and abandoned mine, where no measurements could be obtained.

The coal evidently rises both ways from Saw Mill run at this point, for it shows on a left hand fork of the creek, due north of Castle Shannon, at the *McDonough pit* at 987′ A. T. and at *G. Weidinger's pit* on the main stream at 952′ A. T. close to where the coal finally disappears beneath water level.

Returning now to the river, the outcrop, after leaving the Beck's run bluff, turns south-east towards Street's run, rising south-east at least to beyond Baldwin's station where it is opened at *Walton's Six Mile Ferry* works, nearly 300′ above the river, at 1000′ A. T.

A partially concealed section here shows:—

Pittsburgh coal bed,	1000′ A. T.
Shale and thin sandstone, mostly concealed, massive at the bottom,	80′
Shales; brown and drab,	30′
S. S. and sandy shales; yellow,	45′
Red shale and clay,	15′
Reddish and olive slates,	20′
Gray shales,	15′
Red rocks; and concealed to river,	85′

All the front coal is worked out at these mines, the workings extending far back into the hills and largely drained out into Wilson's hollow, a branch of Beaver run, the latter flowing eastward to Street's run. The coal at this rear pit mouth, at the head of the crop, is 990′ A. T. or only 10′ lower than the front coal. However almost all this coal is drained out of this pit mouth, the true face entries sinking south-west at about 20′ per mile. It is claimed that all the coal on the west side of the tunnel, towards Hays, should naturally drain westward into Hay's works, and thence to Saw Mill run waters. In the absence of developments and elevations at comparative points in the two bodies of coal, it is difficult to say whether the view be correct or not; but certainly the coal on the *east* side of Walton's tunnel dips and drains south-east into Street's run. and it is more than probable therefore that somewhere between the two workings a local anticlinal will be found, turning the water both ways;—*and this line will mark the position of the Nineveh synclinal axis.*

Several branches of Street's run cut deeply into the area of coal in the north-eastern section of the county, the first on the north especially spreading the outcrop on either side of it, and obliging the Walton mine to span it with a high trestle 700 yards long, from the rear pit mouth of the first hill (1010′ A. T.) to the front pit mouth of the second hill (1000′). The front hill tunnel is largely run through the roof coal for grade (850 yards long) in which the following partial section was obtained :

Roof division, partly concealed.		
Coal,	5″	2′ 1″ +
Slate,	$\frac{1}{4}$″	
Coal,	5″	
Slate,	$\frac{1}{4}$″	
Coal,	4″	
Slate,	$\frac{1}{2}$″	
Coal,	6″	
Slate,	$\frac{1}{2}$″	
Coal,	1″	
Slate,	$\frac{1}{2}$″	
Coal,	2″	
Main clay parting,		10″
Lower Division,		
Breast *Coal,*	3′ 0″	5′ $4\frac{1}{2}$″
Slate,	$\frac{1}{4}$″	
Bearing-in *Coal,*	4″	
Slate,	$\frac{1}{4}$″	
Brick *Coal,*	8″	
Bottom *Coal,*	1′ 4″	

The roof coal is only partially exposed, and in all is about 4′ thick. This is a representative section for all this part of the field. The average run of coal at this mine is 18,000 bushels.

One swamp passes through the mine about 800 yards from the pit mouth and 15′ deep, and slopes downward *north-west,* causing a dip in that direction along the rear tunnel.

The production here is reported with the Walton upper workings at Elizabeth, and shows a grand total of 177,765 tons.

As before mentioned, the Pittsburgh coal is nearly at water level at Walton's rear pit mouth, on Beaver run at 990′ A. T. A short distance further down the branch, south-east, it shows at *Cowan's pit* at 965′ A. T. ; below mouth of next branch at 942′ A. T., just above the Grape

Vine Inn, and finally near the Street's run synclinal, at *Reily's pit* at 935′ ± A. T.

South from Beaver run the coal extends up the main stream and along the B. & O. R. R. for over a mile and a half, finally disappearing at John McKees at 945′ A. T. A valuable coal territory awaits development on both sides of the creek here, as from surrounding elevations, the coal must be quite in the trough here, while rising south-east rapidly to the Pin Hook axis and more gently north-west to the subordinate anticlinal already spoken of.

The Redstone coal bed shows near the extreme south-east of this township at 975′ A. T., the Pittsburgh coal appearing a little further down Lick run at the junction of Jefferson, Baldwin and Snowden townships, and rising from the creek south-east towards the Pin Hook axis. Along the Wheeling Division of the B. & O. R. R. and between this point and where it leaves Street's run, the country rises to 250′ above the Pittsburgh coal, showing imperfect exposures of the Great Limestone.

Snowden township lies south of Baldwin and Scott, Lick creek dividing it on the east from Jefferson, while to the west it borders on Upper St. Clair township. It lies immediately north of the Washington Co. line.

It is drained principally through Piney fork of Peters creek and its tributaries, and Lick creek south-east, although a considerable portion of the northern area is drained through McLaughlin's and Saw Mill run westward. The Pinhook anticlinal crosses the south-east corner of the township, elevating the Pittsburgh bed over a considerable area along Lick creek, Piney fork and Catfish run, and rendering accessible almost to the village of Library. In the north-western portion however the coal is deeply buried at least 200′ beneath the surface of the ground. The highest rocks in the county occur about 300′ above the coal; the lowest 100′ below it in the south-east corner.

Limited and unsatisfactory exposures of the Upper Productive Measures show in the centre and north-west, with occasional thin coals, possible representatives of the *Waynesburg* and *Washington* coal beds; though this is merely provisional, all exposures failing for the compilation of a vertical section. School House No. 7 is in line with the south-west extension of the Nineveh synclinal, and to the north-west of this, near the cross-roads on the ridge, what is probably the *Washington coal* crops about 18″ thick.

On the head waters of McLaughlin s run, the Great Limestone shows, shaly and impure, the whole mass being 70′ thick.

Along Piney fork the Pittsburgh coal rises from the stream just below the village of Library (965′ ± A. T.) where it is opened at *Henry Potter's pit*, close to the public road at 935′ A. T.*

The coal here (breast and brick) is about 5′ thick and the bottom coal 2′, making the whole lower division 7′.

The general appearance of the coal is excellent, breaking out in large lumps; some little mineral charcoal in places, and occasionally good sized "sulphur balls". This coal is also opened at *Lauterbachs*, and *Siebolds*, further south-east, the latter at 985′ A. T. both in a branch hollow leading up to the 12 Mile House.

Further south-east, up the same ravine, the coal at *Higbee's* is at 1005′ A. T. and finally at *Bowles pit* 1010′ A. T., showing the steady rise south-eastward to the anticlinal near 12 Mile House. Here on the summit at the cross-roads a limestone shows at 1135′ A. T.

At all these openings the coal is practically similar, although the lower division does not show quite as thick at Potters, varying from 5′ 6″ to 5′ 10″.

On the Brownsville road 1½ miles north of the 12 Mile House, the coal is opened at 1020′ A. T., dipping here south-east. Every farmer hereabouts has opened the coal, and the pits are too numerous to locate. Thus Handel, Hargers and Glenn, on Catfish run, are all west of the axis, and at 987′, 977′ and 950′, respectively, going north-west.

On Lick creek, the anticlinal passes near *J. King's pit* at 1027′ A. T., the coal dipping both ways from here.

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*The elevations through this portion of the field are necessarily based upon B. & O. levels, upon which I have no reliance. They are *relatively* correct but uncertain as to tide datum.

Up stream it crops to beyond Wallaces, showing in this township at John Wallace's 998′ A. T.; L. McElhaney 969′; James Wilson 953′ and finally below Curry Sta. at *Wallace pit* 931′ A. T.—upon which fixed elevation all these others have been adjusted.

South-east of the axis the coal is opened down Lick creek at Abers (Woods) pit 1017′; ditto second pit 1001′ and Bedell old pit 922′ near the railroad, finally cropping just beneath public road, facing the B. & O. R. R. at Bedell's new pit now *Pittsburgh and Chicago Gas Coal Co. Mine No. 2.* It is situated about 30′ above the track at Snowden station, 17 miles by rail south of Pittsburgh. No reliable railroad data could be obtained; but based upon the Wallace pit (931′ A. T.) the coal here would be 895′ A. T. and the railroad about 865′ A. T.

This mine when visited early in 1885 was entirely idle, and had not been driven far into the hill. The front coal is quite narrow, contained in the point between Lick run and Piney fork. It was opened on the double entry system, the main tunnel being about 175′ long, and a little off butts, and then quartered south-west for 350′ to a knuckle, the coal draining from this point out to Piney fork and main pit mouth.

A swamp (narrow and deep) extends from the knuckle N. 57° E. towards Lick run, and about 500 feet long. The coal in the swamp is about 5′ 6″ thick; outside the swamp it shows: Main clay 6″–8″; Breast coal 3′ 6″–3′ 8″; Bearing in coal 2″–3″;Brick coal 8″–10″ and lower bottom 1′.

Peters creek cuts down deeply into the Barren Measures.

Mifflin township lies east of Baldwin and north of Jefferson, with a long river front on its north and east sides from Streets run to Coal Valley.

The township is thickly settled and largely developed. The most prominent and economically important feature of this township is the great Pin Hook anticlinal, which nearly divides the area in two, though as usual the north-west slope of the axis is shorter than the south-east. The arch of the Pin Hook axis is broad and regular here, and it would be impossible therefore, in the absence of actual development to locate exactly the axial plane. But from the numerous coal openings in this township, and the great regularity of the measures over wide areas, the main features of structure are plainly displayed.

The Pin Hook axis may be drawn as a practically straight line, about N. 35° E., from the crossing of the middle branch of Lewis run, through Espey's forks, Lebanon church and school house, the headwaters of Thompson's run, the head forks of Whiteacre run to the Monongahela river opposite Braddocks and about ½ mile below Green Springs Sta. Indeed in a general way, the Pin Hook axis between the Washington Co. line and the Monongahela river is sufficiently located by a N. 35° E. straight line from the 12-mile house in Snowden Twp., through the M. E. church in Jefferson Twp., and the Presbyterian Lebanon church in Mifflin, and extended to the river. There may be some little variation in the axis line at local points; but in a general way the statement will be found correct.

Its rate of rise north-eastward in Mifflin Co. seems very slight, though in other parts of the territory crossed by this axis, the rise is very marked.

To the south-east of the Pin Hook axis the coal falls about 40′–50′ per mile to the river, the synclinal between this and the Roaring Run axis occupying that portion of the township north of McKeesport, around which the river makes such a wide bend. There is altogether a vertical thickness of about 550′ of rocks exposed in the township, 200 of these being the Upper Productive Measures with the Pittsburgh coal at the base. The highest summits are probably at the Morton and Patterson places respectively 1,200 and 1,295 A. T.

Streets run on the west divides Mifflin and Baldwin Twp. from the Monongahela river almost to the Jefferson Co. line. It likewise approximately marks the position of the eastern sub-division of the *Nineveh synclinal*, which however is but indistinctly indicated, owing to the coal soon passing beneath water level and the paucity of other exposures. This sub-division is a tight, narrow fold. The plane of this Nineveh trough is likewise inclined to the S.

W. dipping in that direction about 25′ per mile for four miles, as indicated by elevations of the Pittsburgh coal at Calhoun's pit and its disappearance on the Garrison lands on Streets run. This valley is deeply eroded, the coal at the river front being up in the hills over 300′ above the Monongahela river.

The horizons of the Redstone and Sewickley coals are frequently met with, but rarely are these beds found and as far as I know, are never mined. The Crinoidal limestone is exposed below Thompson Sta. and is thus described in Rep. K., p.303. * * "It varies in thickness from 8″ to 1′. It is bluish-gray, coarse grained, resembling sandstone, looks soft, but does not disintegrate readily, and stands out in blocks along the bluff. This rock is exceedingly fossiliferous here, ten species of mollusca, together with immense numbers of crinoidal plates and spines, having been found in one block." South along the river towards McKeesport, the "Barrens" red and variegated shales show 12′ to 15′ thick at Germantown, succeeded going south along railroad by Morgantown sandstone, forming great cliffs and bluffs along the river front, composed of a massive blue and gray sandstone.

The Pittsburgh bed is opened in nearly every ravine in the township, so that the structural features were located here with considerable accuracy. Along Streets run the coal is first opened at the old *McKee pit*, close to where the coal disappears under cover. It is proposed to work the extensive lands of A. Garrison in Mifflin and of Jno. S. Scully in Baldwin, from this central point.

McKees opening is about (945′ A. T.) and the coal shows:

Roof division 3′ 4″ to 3′ 6″; clay parting 6″–8″; lower division 5′ 1″.

The upper sandstone is exposed 10′ thick above the coal, from which it is divided by 12 to 15 inches of black shale. The roof coal is generally bony and dull. The lower bottom coal is 13 inches thick and worthless, leaving 4′ of breast and brick coal.

The apparent dip here is S. E., but the coal really rises in that direction to the Pin Hook axis whose crest here must be fully 100 feet higher.

In the next ravine north the Pittsburg coal is again opened at the old Weir farm pit at 1038′, whose coal is owned by Lysle & Co., and again ½ mile north at the Patterson pit at 1043′ at the head of Patterson's hollow. At both places the coal dips N. W. A short distance north from here, is the first of a series of openings made by the Hays Est. The first opening at 975′ A. T., is the lowest of all the openings between Streets run and Hamilton hollow, and consequently drains the swamp that was found in this property.

These mines were not in operation when visited in 1885, and consequently no detailed examination of the workings was possible.

Proceeding northwards along Streets run the coal is found always rising along a line parallel with the axis, as well as to the south-east towards the Pinhook anticlinal. Thus openings have been made in four places and the three most northern gangways have been carried to daylight in Hamilton hollow south-east.

The most northern is 1890′ long S. 65° E., and shows no difference of level at the ends. However for 1250′ from the west opening the coal dips 9′ to the centre of the swamp and apparently near its head.

The second butt entry is 2930′ long, the centre of the swamp being at 2150′ from the Streets run crop and 12′ lower; and further south in the third parallel butt entry, 2760′ long, the swamp is 7′ lower than the west opening and 1600′ S. 65° E. from it. The curious feature of this swamp is its greater elevation in the central gangway, which however can be readily overcome and the entire swamp drained out at 975′ A. T.

South of Hays works and Hamilton hollow, I. D. Risher has opened some new works. The new pit mouth is 1030′ A. T., the Pittsburgh coal apparently dipping to the S. W., and is again exposed in the railroad cut just north of Risher's at 1010′. To the south from Risher's the coal is rising going up ravine; finally going under cover at *Hills country* pit at 1035′ A. T.

North-west over the divide this coal is again opened in a flat below A. Millers old house, at 1032′ and probably still on the north-west side of the axis, though not far from it. None of these openings were sufficiently developed to show much, but the evidence they do afford is all towards placing the axis to the east of them. The breast coal in them will average about 3 feet; parting 3 inches; brick coal 8 inches, and lower bottom 14 inches. The roof coal was not opened. This country will be largely developed by Risher's new railroad, joining the Wheeling division of the B. & O. R. R. at Hope Church station.

To the north, the valley of Streets run gets deeper and the Pittsburgh coal bed higher in the hills, until it is opened on its extreme north-western outcrop, *south* of the river, and east of Hays station at 1045′ A. T., at *S. Calhoun's* country pit, about 340 feet above the river.

This opening is close to the public road, and has a comparatively light cover. The coal is opened on a butt entry S. 66° E. The breast coal is about 3′ 4″ thick, the bearing in coal 4½″, and the brick coal 10″ thick.

The coal dips locally along the butt entry, but not for any considerable distance. The coal is higher to the south-east, being opened a little over a mile distant, by *R. Calhoun.* This is likewise a country pit, opened on the west side of the public road, and about ½ mile south of the Franklin church.

The elevation here approximates 1058′ A. T., and the coal is opened S. 10° W. The coal along this entry dips as it goes in, which is natural, owing to the general south-west slope of all the measures.

Still another pit is opened in *G. Wesley's* orchard, about 400 yards east of the last, and on a branch of Whiteacre run. Its location is shown on the map, and though but little south of Calhoun's pit the coal shows a fall of 18′ to 1040′. This difference is abnormal, and can only be accounted for by a local swamp between the two pits.

Between these three last mentioned pits there is no coal along the river front, the erosion of West and Whiteacre runs keeping the coal fully 2 miles south of the Monongahela at Homestead.

Even the rock exposures of the Barren Measures are scarce and imperfect. However those seen along the P. V. & C. R. R. seem to rise to show a the south-east to within 600 yards of Green Springs Sta. south of which the reverse dip is noticed, though obscure. Here then is the *Pinhook axis.*

The hill along the river immediately south of Green Spring station is high enough to catch the Pittsburgh coal, which is here opened by T. Fawcett & Co. at the *Green Spring mines.* The river pit mouth, at head of incline plane, is 1062′ A. T. and is located on the east side of the broad and flat Pinhook anticlinal. The works were idle when visited, but have been counted as one of the most extensive on the river. In 1885, only 10,800 tons were mined- The dip is south-east; and the coal likewise slopes and drains to the south-west.

Some 300 acres of the river front hills have been worked out, and the present unmined territory is all situated back in the third hill about 1¾ miles from the river. The south end of the first hill tunnel is 1056′ A. T. a fall of 6 feet *along the axis*; the south end of second tunnel is at 1043′, or a fall of 19 feet. Here a surface road crosses a branch of Whiteacre run, entering the third tunnel at 1038′ A. T. All these elevations represent the *south-west* fall of the coal, and *not* the *dip*, which is to the south-east.

An extensive wire rope plant is in operation here, the stationary engine being located at the river pit mouth. The plane to the river tipple is 266 yards long. Owing to idleness, only a casual inspection of the main tunnel could be made. The mine is reported to have developed a large swamp, which (K.[4] p. 161) is 7½ feet in depth and 200 yds. wide, bearing S. 20° W. The swamp is not located, but from the bearing given, it may simply be a fall along the face of the coal, the water naturally collecting in any gangway driven in a south-west direction. The coal elsewhere through this part of the township is comparatively free from serious irregularity of dips, which "swamps" really are, and it would seem that the best possible point of attack for this coal would be from the south-east, along Thompson's run, where the advantage of a north-west rise in the coal of fully 60 feet to the mile could secure both good drainage and economical haulage.

A section of the lower part of the bed in the main tunnel shows:

Main clay parting, ...		10″	6′ 6″±
Breast coal, ...	3 to 3′	6″	
Parting, ...		$\frac{1}{4}$″	
Bearing in coal, ...		5″	
Parting, ...		$\frac{1}{4}$″	
Brick coal, ...		10″	
Parting, ...		$\frac{1}{4}$″	
Bottom coal, ...	1′	8″	
Under clay, ...			

The roof coal is about 5 feet thick, but as usual through this region, utterly worthless, occurring in seams between slate and clay, rarely over 6 inches thick.

The main over-clay is reported regular throughout the mine; the rolls and horsebacks occurring in the roof members with a tendency to compress the breast coal slightly from 4 to 6 inches. The bottom coal is not lifted.

South-west across the hill from the entrance to the third Fawcett tunnel, the *Bellwood mine* of Munhall Bros. is opened at 1033′ A. T.

From here a surface road $2\frac{1}{4}$ miles in length leads down the valley of Whiteacre run to the P. V. & C. R. R. near Munhall Sta. 751′ A. T.

Here likewise everything was idle, but I learned that shipments average 10,000 bushels of lump coal per day. The run of mine yields 75 per cent. lump and 25 per cent. of nut and slack coal. The production in 1885 was 36,800 tons.

Single entry system is pursued entirely, the main entry quartered S. $36\frac{1}{2}$° W. and the butt entries driven singly 165 yards apart. The coal has but little cover and the mine is readily ventilated by shafts from the surface.

The workable coal is quite similar to the Greenspring's section; the over clay and bottom coal are rather thinner. The coal dips to the south-east.

One mile south-east, *Cochrans country* pit is opened on the north side of the public road leading up a branch of Thompson's run. The elevation here is 992′ which fairly represents the dip—40 feet per mile—on the south side of the Pin Hook axis. The coal here is now owned by Munhall & Co. The old pit entry is opened nearly on the face N. 27° E.—and the coal looks well.

The Connellsville sandstone is slightly quarried in the creek bed below (south) at 916′ A. T.

Most of the coal between Thompson run and the river has been worked out, and the old works of Neel and Neel & Oliver on the Monongahela river below McKeesport are long since abandoned.

The coal lies comparatively level through here and under good cover. On the public road, 110 feet above Thompson run at the old saw mill, there is a country pit opened at the road side. This was one of the old pit entries on the Col. John Neel property at 968′ and still shows a south-east dip in the coal. At the old village of Germantown, the rear opening to Neel's river hill works is at 956′. Only pillars and entry coal remain in the hill.

The most northern opening, formerly *Neel & Oliver's* on the river hill front, is at the same elevation (956′), showing the flatness of the coal and probably marking the synclinal between the Pin Hook and Roaring Run (Murraysville) axes. This pit is just at the point of a narrow ridge within a small ravine heading up back of it. Below the coal, 150 feet, there is a fine exposure of the Morgantown sandstone forming the river bluff for some distance south, while also sinking in that direction.

At this point it is massive and gray-blue in color, 30′± thick, with 20 feet of shaly sandstone cover. The whole mass is from 60 to 70 feet thick. Beneath there is about 50 feet of shaly sandstone to the level of the railroad.

The next pit south, nearly opposite McKeesport, marks the position of the old Neel Coal Works, at 946′ A. T. The Pittsburgh bed here is said to have furnished, on an average, 4½ feet of clean coal. Four Beehive coke ovens were run in connection with these works; all now abandoned. Adjoining this pit on the south is another abandoned pit belonging to the same firm at 946′. This was the largest and the principal opening, and the section visible at the pit mouth shows Breast coal 3′ 6″; Main over-clay, 8″ to 9″. Roof coal and slate 4′ 2″. The side hill shows shale and sandstone beneath the coal to the public road, where the Morgantown sandstone outcrops. At this point this sandstone has a shaly bed 4′ thick at 6′ from bottom. Towards McKeesport it becomes massive again and 40′ thick, though slightly discolored. It is largely quarried for flags and curbing stones.

The next works to the south, facing the village of Reynolds are the Stone Bros. *Coal Valley mines* situated near the north end of Dravosburg on P. V. & C. R. R. While further south than Neel's coal openings, the river pit mouth and outcrop coal is also further west, and nearer the anticlinal, so that the main opening is higher at 965′ A. T. They are among the most extensive, best equipped, and most regular mines in the Second Pool. The front hill coal is narrow here, owing to a branch of Thompson run heading up back of the hill, along which the outcrop of the Pittsburgh coal bed extends to within 200 yards of Fays house on the public road.

The bed here yields about 4½′ of coal with the usual bearing-in slate. Of this, the breast coal is about 3′ 8″ thick with a small ¼″ slate 6″ from the bottom; brick coal 1′ and in addition about 14″ of lower bottom coal. The over-clay is 6″. The roof coal is about 6 feet thick, but as usual, rendered entirely worthless by clay and slate bands, and is not mined. The output is about 15,000 bushels per day, screened into lump and slack coal at the check house, the tonnage for 1885 being 71,178 tons. The coal is pure and readily mined, clay veins being rarely found, though occasionally a little trouble is experienced in the main over-clay from rolls and squeezes. These mines have been operated for over 40 years, the present operations being well back in the hills and perhaps close to the anticlinal. The coal is hauled from the interior by mules and thence through several tunnels by a locomotive to the check house.

The mine railroad is graded exactly on 26 feet to the mile and carries that rise north-west with the coal for at least 2½ miles.

The mine is ventilated by furnace power. The furnace dimensions are: Length, 18 feet; width, 6½ feet; height, 5 feet. Shaft and stack together amount to 80 feet in height.

The outcrop of the Pittsburgh coal is beautifully exposed in the valley and along the numerous branches of Thompsons run, constantly rising on to the Pin Hook axis.

On the north side of the first hill at Stone Bros. works, the coal crops at 973′. The tunnel is about 500 yds. long and the coal rises 8 feet. Crossing the public road at grade here, the track enters the second hill on the coal level, emerging at north side in the main valley at 985′, a little over 1200 yds. in an air line from the main pit mouth.

One branch here crosses the valley north-west and enters the third hill, north-east of the Union church at 1004′; the other branch turns almost due west, entering the hill west of Rev. McClure's house at 1005′, rising from there N. W. to 1036′, not far from the anticlinal. Another one of the gangways of these extensive works crosses just under the public road north of Gildays smith-shop where the coal has but little cover at 1014′.

This is the most northern limit of the crop in this valley, extending thence south-west a little farther around the main stream, where two of Risher's *Amity mine* pits are shown on the map at 1004′ A. T.

Between the crop on Thompson run and that in Hamilton hollow and the branches of Streets run, there is not more than 800 yards of coal beneath road leading over the summit from Gilday's shop.

The ridge between is relatively low, but marks at once the divide of the waters of these two streams and the position of the Pin Hook axis. Outside the exposures of the Pittsburgh coal, which are numerous and well defined, the remaining geology is imperfect and barren of exposures, especially in the Upper Productive measures.

About 400 yards south of Stone's works on the river front are the abandoned *Dravosburg mines*, opened some 40 years ago by Jas. O'Neil. Something over 250 acres have been mined out here, and the property is now incorporated in the *Amity mines* of Jno. C. Risher, situated about 1100 yards south-west from Stone's. The coal here lies well back from the river front which necessitated the building of additional track 750 yards long to reach the crop.

The pit is opened in the *second* hill at about 977′ A. T., or about 260 feet above the river, in a narrow ravine, after passing through a short tunnel in the first hill. From here the main gangway enters on a butt (?) entry north-west 1100 yards ± long to R. B. Neil's house on Thompsons run, and enters the next hill at 1004′ A. T., 27 feet higher at a distance of 1300 yards. The country between rises to 1200′ A. T. at the Morton summit, catching areas of the Great Limestone, but giving little evidence of the presence of either the Redstone or Sewickley coal beds. They are both generally thin or absent from this township.

The output averages fully 15,000 bushels per day when active, employing about 200 men in the service. The cars are hauled by mules to the check house. Possibly 275 acres still remain to be mined here. Total output in 1885 was 54,938 tons.

No personal examination of the mine could be made owing to the enforced idleness of the region during the summer of '85; but the coal seen at the pit mouths measured about 1 foot of main clay; 3′ 2″ of breast coal; 4″ of bearing-in, and 1 foot of brick coal, with the usual $\frac{1}{4}$ inch partings between the members. The bottom coal is probably 12 to 14 inches thick.

An irregular shaped, curving swamp, 14′ deep and 600′ in width is reported here.

Along the stream south of Risher's Amity works, the Pittsburgh coal bed keeps well up on the hill sides, and its outcrop heads up to within 500 yards of the Pin Hook axis at the Lebanon church and school house. At Camden Station, on the P. V. &. C. R. R. (748′ A. T.), the Pittsburgh bed is again opened at the *Camden mines* (Geo. Lysle & Sons) nearly 200 feet above the railroad at 943′ A. T. The mine incline is laid through a deep valley, commencing with brown shales and showing gray sandstone and shales

(Morgantown?) at 780′ A. T. below check house. This point is 420 yards from the river tipple. From here to the upper check house at the front pit mouth, the incline is much steeper, rising 50 yards in 420 yards. A well arranged, excellent double drift is opened in the first hill, the coal rising north-west through the first tunnel 1300 yards to the north crop at 1037′ A. T. All the coal in the front hill is worked out, the track crossing the rear valley and entering the second hill at P. Harts, where the present workings are carried in. A large tract of land is controlled on the north side of the anticlinal by this company, where, after arching over the axis, the coal again outcrops with a north-west dip at the old Weir farm pit at 1038′. Between these two outcrops the country rises rapidly to the Patterson summit at 1295′ A. T. where about 150′ of the upper coal measures are exposed above the Pittsburgh coal, crowned by the Great Limestone, with gray shaly sandstone 25′ thick below it, capping the Sewickley coal, here thin and impure.

The average thickness of the bed in the Camden Mine will show:

Main over clay 6″ to 8″; Breast coal 3′ 2″; Parting $\frac{1}{4}$″; Bearing-in coal 5″; Parting $\frac{1}{2}$″; Brick coal 11″; Parting $\frac{1}{4}$″; Bottom coal 12″ to 14″. The Roof Division is about 4′ thick. The lower bottom is not worked and even the brick coal is rather pyritiferous, although the coal has an excellent reputation for gas purposes. The output in 1885 reached 50,308 tons.

The *Alequippa mine* (Bailey, Wilson & Co.) is opened on the river front a short distance south of Camden station at 920′ (?) A. T. Between this and the Camden mine a ravine intervenes cutting out the coal which, however, circles around this stream, and approaches the ravine much closer at the Alequippa mines.

The tunnel in the first hill, about 900 yards long, emerges in a branch ravine from Pine run, 17 feet higher at 938′ A. T. and the coal at this place shows a marked south-east dip. The line of this tunnel is nearly east and west. A surface track 150 yards long crosses the public road here at grade and enters the second hill at 940′ to the present workings in the fourth hill. The workings are very extensive and the gangways are planned to develop across the axis to the old *Rath pit* at the head of Lewis run at 1047′ A. T. The coal at present, owing to the reverse dip, must be hauled up grade to a point in the third hill; from there the dip is strongly south-east and the cars are run out in long trains by gravity to the check house a distance of 1300 ± yards. The output is over 15,000 bushels of lump coal per day. the total in 1885 being 58,334 tons. Much natural ventilation is gained here owing to the proximity of the inside workings to the crop along Pine run and the number of gangways to it.

A section here shows:

Roof coal with clay and slate partings (worthless),	5′	+	
Main over clay,	0′	6″	
Breast coal,	3′	6″	6′ $\frac{3}{4}$″
Parting,	0′	$\frac{1}{4}$″	
Bearing in coal,	0′	4″	
Parting,		$\frac{1}{4}$″	
Brick coal,	0′	10″	
Parting,		$\frac{1}{4}$″	
Bottom coal,	1′	4″	

The last opening on the river in this township, just south of Rock run, is the *Rock Run mine* (W. J. Snodgrass) at 918′ ± A. T.

The tunnel through the first hill is about 550 yards long, crossing the north fork of Pine run by a high (abandoned) trestle, and entering the second hill at 938 A. T. The drainage and dip are strongly south-east.

The mine was idle when visited and no personal information could be obtained.

Horse backs and *clay veins* are reported as numerous, reducing the size of the lower members.

This is probably the beginning of the trouble that becomes prominent further south in Jefferson township. The coal in the Rock Run mines, when not influenced by the crushing of the over-clay, shows the usual thickness 3½ feet of breast, 4″ bearing-in, 10″ brick and 1′ 3″ lower bottom.

The output here in 1885 was 28,808 tons.

The Pittsburgh coal on Pine run rises well on to the axis, the two last forks of the stream both heading in the high country marked by the anticlinal. The most northern pit at 1030 ± A. T. is just where the road crosses to go to Espeys. The opening shows the lower division of the bed as Breast coal 3′; Bearing in 4″; Brick coal 9″; Lower bottom 14 inches. From here the dip is south-east for 2 miles to the river, falling about 100′ or 50′ per mile. A little below this opening is *McGowan's pit* at 1000′ ±; Roof coal 2′ +; Main clay 1′; Breast coal 3′; Bearing in 4″; Brick coal and Lower bottom (the latter poor) about 1′ 10″.

Below the Snodgrass openings on Pine run, the lower limestone is well exposed about 4′ thick. The Barren Measures beneath outcrop further down along stream to Coal Valley Sta., especially a heavy sandstone, quarried a little above the road bridge. A small 4 inch coal seam, divided in the centre by 1″ of clay, occurs in red and brown shales 100 yards above the creek bridge. Red clay comes in about 1′ beneath it. The coal is not persistent and is seen in the road cuttings. Much of the mine drainage from the Alequippa, Camden and Rock Run mines is turned into Pine run and thence to the Monongahela river.

Owing to the almost universal idleness during the summer of 1885 it was well nigh impossible to get any information upon special features at these different works, and demands elsewhere prevented a further examination of this field in 1886.

Jefferson township joins Mifflin on the south and Snowden on the east, and occupies all that south-eastern portion of the county fronting along the Monongahela river from Coal Valley, near the Mifflin line, south to Washington Co.

The P. V. & C. R. R. follows along the river and the eastern border line while the Wheeling Division of the B. & O. passes down Lick creek for the further development of the rear portion of the township.

The *Pinhook anticlinal* passes through its north-west corner from Lewis to Lick run as already described; the *Roaring Run anticlinal* extends along the eastern side of the township south of Blair's station and nearly parallel to the river, while the western subdivision of the *Waynes-*

burg synclinal describes a sinuous course, from the river at Rock Run station to Peters creek near the mouth of Lewis run, and thence south-west nearly parallel but east of that creek to the Washington Co. line at about 1¾ miles from the river.

The coal developments are almost as extensive as those of Mifflin Co. although a large area between Lewis and Lick creeks and north-west of Peters creek, is still untouched save by small country pits.

Peters creek and its numerous tributaries have cut down deep trenches in the Barren Measures, while at the same time cutting out a large area of coal.

The rock section extends from 80′ above to 350′ below the Pittsburgh coal, the lowest rocks being exposed along the river bluff.

The rapid rise of the Roaring Run axis from the Washington line to the river, assisted by the erosion of Peters creek, has obliterated all signs of the Pittsburgh coal and overlying measures along the river front from a little north of West Elizabeth to beyond Wilson's Sta. on the P. V. & C. R. R.

The most northern operation in this township is the *Pine Run mine* (John O'Neill), located about 1½ miles from the river at 880′ A. T. (Abers coal) beyond which the company's road extends some little further to the head of the coal crop, where the *Finney mine* of the same company is opened at 912′ A. T. A large part of the latter coal area lies in Mifflin township, and rises regularly and without serious interruption north-west to the Pinhook axis.

But in the Abers coal further down the creek considerable trouble has been experienced from a canoe-shaped swamp, without outlet, several hundred yards in length, 200 yards wide in places and 50 feet deep.

Unfortunately no personal examination of this mine could be made though it was twice visited in '85 during the great strike which demoralized this whole region. The swamp extends apparently in a westwardly direction towards Mrs. McKees house. The Pittsburgh coal is abnormally thick in this swamp and dips rapidly along a face entry S. 25° W. On the north side of Pine run the coal is opened, with its normal section, and fully 20′ higher or at 900′ A. T.

Considerable difficulty has been experienced in mining this swamp coal, and the story is repeated in many places between here and Peters creek—or in other works immediately on either side of the synclinal basin.

The output at this mine in 1885 reached 34,390 tons.

The *Blackburn mine* (Foster, Clark & Wood) is situated on the east side of the basin, although the workings extend across the trough to daylight in a branch of Lewis run. The interruptions to systematic mining occur here on every side. The front pit mouth is located about half a mile from the river at Coal Valley station and at 895′ A. T. A tunnel passes through the first hill to a ravine, which is crossed, and the second hill entered. The coal here is 904′ A. T. and falls rapidly south-west in the second hill to a point under the township road at 879′. Two swamp entries drain the coal from here, west and south-west into Lewis run. The swamp is very irregular in shape and size. Output in 1885 was 41,500 tons.

The hill immediately over this coal rises to 1150′ A. T. and shows an imperfect section of the Upper Productive Measures, crowned with the Great Limestone (earthy) and commanding a superb view of the surrounding country. On the township roads leading to this summit all exposures are meagre, and no sign of either the Redstone or Sewickley coal beds was seen.

Up Lewis run the Pittsburgh coal is above water level to beyond the township line and into Mifflin, opened at numerous abandoned country pits.

On Beams run the crop is also carried well north-westward, owing to the influence of the Pin-Hook axis, the coal rising constantly from Peters creek to beyond the Gillhall smith shop about 950′ A. T. On both creeks the roof division shows about 2′ 6″; main clay parting 6″–10″ and lower division 5′ 6″.

The same is true of Lick creek, where two openings occur at the head of first small ravine, and back of machine shops, respectively *Curry 986′* A. T. and *Hindman 991′* A. T. In both the coal looks very well, rising north-east, and north-west up stream to *Doughty's* 1001′, quite an extensive country pit opened opposite Cochran's mill.

The coal still rises north-west until the axis is crossed, after which it is again opened on Mineral run branch at about 985′ A. T., leaving the township just below Wallace's bank. Much cheap and good coal will be won from this part of the township. The openings along the river are numerous, the largest and most important being those of Jos. Walton & Co.

Walton's lower mine workings are immediately back of West Elizabeth, entering the outcrop at 976′ A. T. and passing through two hills to the dilly pit mouth in the third hill at 946′ A. T. The coal rises slightly at first until the expiring Roaring Run axis is passed, when it dips steadily into the synclinal passing through the rear workings close to the crop along Peters creek.

Here again a serious swamp exists, which to my mind, closely marks the trend of the basin.

The rear crop is opened in several places for ventilating these workings; at Bedells north and south pits at 894′ and 889′ A. T. and Hoffman's pit 889′.

Lobbs run, which enters the river below Lock No. 3 forks at about 1½ miles from the river, the north branch extending up to Calamity and exposing the Pittsburgh coal up to Converson's store at 901′ A. T.

A little below this *Walton's upper pit* enters the west hill at 884′ A. T. and in a ravine south-west of this *Walton's New mines* were just being opened (July '85) at 871′ A. T. The main entry was turned S. 52° W. a little off butts, and at the face of Room No. 1 in No. 3 Butt entry the mining coal showed: breast, 3′; bearing-in coal, 4″; brick coal, 1′; the lower bottom not being raised. Occasionally in the lower end of the mine there is a small band of sulphur visible about 8″ above the bearing-in; but while it is persistent for some little distance in places, its occurrence is rare. It was proposed to drive the main gangway through to Peters creek for drainage; but late advices indicate the presence of the same swamp and synclinal met with in the lower works, which will make drainage troublesome. The elevations of the crop along Peters creek vary little from that of the main pit and the coal there evidently dips south-east. From Lobbs creek it dips north-west.

Openings along Peters creek are the *Shepler pit* 874′; *Finley pit* 870′; *Pierce* 869′; *Castor* 869′. The coal is about 75′–100′ above the creek, and is still higher on the west side of the creek. The country to the south rises to about 250′ above the coal, though neither the Redstone or Sewickley beds were noticed.

From 80′ to 85′ above the coal, Samuel Heath has opened a quarry in excellent flagstone 18′–20′ thick in the Pittsburgh upper sandstone, east of H. Shepler's residence. It is micaceous, gray in color and very firm.

North-west half a mile, just in the public road at Shepler's house, limestone (Fishpot?) shows at 105′ by barometer above the coal; but the Sewickley coal could not be found.

Further east, above the Hoffman opening, the blossom of the Redstone coal shows at 70′ above the Pittsburgh coal, and a portion of the Great Limestone 110′ higher. All the measures are dipping slightly south-east here.

In the river hill, along the south-east side of the township, the Great Limestone shows and is quarried from the hill tops for burning in the neighborhood of J. Rays house, north of West Elizabeth.

Jones mine is situated on the hill back of Jones station and immediately above the school house.

This mine was also idle and no information could be obtained concerning it. The roof coal is about 5′+ thick; main clay 1′; breast coal from 3′ to 3′ 6″; bearing in 3″; brick coal 1′ and lower bottom 1′. Work was confined largely to the front hill extending back to the north branch of Lobbs run. The pit mouth is nearly a thousand yards from the river tipple. The output here reached 31,312 tons in 1885.

The outcrop of the Pittsburgh coal extends up the south branch of Lobbs creek nearly to the Washington line at Dr. Pierces, and rises south-east from here to the river front in Washington Co. to the *Hilldale mine* 869′ A. T.

Chapter VI.

Washington County.

Washington County comprises an area of about 890 square miles, lying between Allegheny and Greene counties, with the State of West Virginia on the west and the Monongahela river forming its eastern boundary, and separating it from Fayette Co.

Topographically its several townships contain quite as high land as those relatively situated in Greene Co., but geologically the two counties, lying so close together, show many striking differences.

The coloring shown on the map tells the story graphically. The structural laws governing all south-west Pennsylvania and causing such vital commercial distinction as between Allegheny *north* of the Ohio and Allegheny *south* of the Ohio, are still in force here. Once this law of *a general south-west sinking of the measures from New York into West Virginia* is thoroughly understood and applied the interpretation of the geology of this district will become a simple problem to its people. Without such a potent cause no such geological effects would exist to-day.

Had the different rock systems of eastern Pennsylvania remained perfectly level from the time of their deposition; or had they been only thrown into simple waves north-west and south-east, parallel with the present anticlinal and synclinal axes, no such contrast would now be shown in the coloring of the different counties. The Pittsburgh bed would be found far north of its present defined limits, covered by as thick a mantle of Upper Productive and Upper Barren measures as conceal it to-day in Greene Co., and probably as inaccessible as it is there.

But this constant rise of the measures going north-east has changed all this in a most remarkable manner. While it has robbed North Allegheny, Beaver, and Butler counties of the great Pittsburgh bed, by exposing it and the accompanying measures to a never ceasing atmospheric erosion, it has generously spread the outcrop of this superb bed through miles of accessible territory, along the great rivers of the district and within easy reach of railroads along branch streams.

And great as has been the draught upon this great storehouse of fuel wealth in the past, to supply the wants of the region, in both its domestic and industrial aspects, the supply is still practically inexhaustible and far beyond the capacity of the human mind to appreciate.

Washington county, separating Allegheny from Greene, partakes of the prevailing geology of each. Throughout its northern portion and along its river townships, the Upper Productive measures have a wide outspread, and occupy more than one-third of the county. In the central and the southern portions of the county, the map will show the large and compact area of the Upper Barren series extending south into Greene Co.

The *Pittsburgh coal*, at the base of the Productive Measures, is naturally under still deeper cover through most of this county than it has already been shown to carry in southern Allegheny. But good exposures of it are found here along the river as far south as Brownsville, and from below Fredericktown to Ten Mile creek. Limited areas of this bed are exposed along Peters creek for over 2 miles from the Allegheny line, and along Chartiers creek, where it is brought up quite extensively by the Washington axis. On Cross creek, along the West Virginia line, and in the area north of the Pan-handle R. R. the bed is largely exposed; but at present, rather inaccessible.

The Pin-hook, Washington, Claysville, and Bulger anticlinals cross the county from south-east to north-west as named; while the Waynesburg, Nineveh, and Mansfield synclinals are the three principal troughs accompanying them, as fully set forth in Chap. III.

The *drainage* of the county is diversified.

Ten Mile, Pike, and Pigeon creeks, with their numerous branches, are the principal streams entering the Monongahela river between Greene Co. and Monongahela City, while

Mingo and Peters creeks contribute additional drainage to the river, north of Monongahela City.

These five streams drain the best part of 13 townships. The Hunter fork of Wheeling creek, forming a portion of the boundary line between Greene and Washington, drains a considerable portion of the south-west corner of the county through its two branches, Robison and Gordy's forks.

Buffalo creek, further north, drains a large portion of west-central Washington into the Ohio river, the four townships of Independence, Hopewell, Buffalo, and Donegal being tributary to it.

Cross creek and Harman's creek (the latter occupied by the Pan Handle R. R.,) while not so large as those just mentioned, drain a considerable territory in north-west Washington Co.

But the chief stream entering the Ohio from this county is Chartiers creek. Of far more importance to Allegheny Co., it is nevertheless a very considerable water course in Washington. Rising south of the central portion of the county, it flows north, north-east past Washington and Cannonsburg, and forms the gateway for the approach of the Chartiers Valley R. R. from Mansfield to Washington. Its principal tribntary is the North fork, which enters it midway between Cannonsburg and the Allegheny Co. line, after draining North and South Strabane townships.

Other important tributaries enter it from the west, until entering Allegheny, it becomes a strong and very important stream meandering in the Mansfield synclinal to the Ohio river.

Except near their sources none of these streams in Washington Co. have a very rapid fall, and owing probably to the large cultivation of the territory and small percentage of woodland, none of them have a great volume of water.

Topography.—In Washington Co. the country is undulating, except in the south-west portion, where the presence of the hard sandstones of the Upper Barrens and the absence of limestones has made the topography somewhat rugged. The county generally is under a high state of agricultural development, and its broad valleys and fertile hills are very beautiful and unsurpassed as grazing ground for sheep.

As a producer of wool clippings, Washington Co. is at the head of the list in the United States, furnishing in the census year 1880, a total of 2,417,000 lbs. The even and thorough erosion of the many limestones of the Upper Productive Measures has created throughout north and east Washington Co., a series of lovely farms which are not subject to much washing out of their soil.

Transportation.—The county is fairly well provided with transportation facilities. The natural advantages of the river for moving freight cheaply and in large bulk, are supplemented by the P. V. & C. R. R. (Monongahela Division of the P. R. R.) extending from West Brownsville down the river front.

The Wheeling Division of the B. & O. R. R. enters the county along Peters creek, and passing through the county seat, extends through the south-west portion into W. Virginia.

The Chartiers Valley branch of the P. C. & St. L. R. R. extends north from Washington via Chartiers creek to Washington, while the Washington and Waynesburg R. R. establishes communication with the county seat of Greene.

Lastly, the Panhandle R. R. skirts the north portion of the county, of little immediate benefit to the district generally, but of great use to the people in the north, and to the development of the coal interests along Robinson and Harman creeks.

Stratigraphical Geology.—The stratified rocks throughout Washington Co. belong to one or the other of the three upper series of the coal measures; 1st, the Upper Barren Measures; 2nd, the Upper Productive Measures; 3d, the Barren Measures.

Upper Barren Measures.

As is shown by the map coloring, the Upper Barren measures (the darkest tint) spreads over fully one half of the area. It comprises all the rocks in the district above the *Waynesburg sandstone*; substantially without important coal beds, but, owing to the outcropping of the lower portions of the series here, at its most northern extension, presenting more limestone beds; creating less rugged topography therefore and a more readily cultivated country.

The double grouping of this series into an upper and lower group, or respectively the *Greene County group* and the *Washington County group* has been fully treated of elsewhere, and need not be rehearsed at length here.

The parting line between the groups has been fixed at the Upper Washington limestone, No. VI of the whole series —being a readily recognized horizon by reason of its strongly marked characteristics. It is about 30′ thick.

Typical sections of each group have been given in chapter IV.

The series is much thicker in Greene than in Washington and shows a still further diminution going towards Allegheny Co.

Although the term *Upper Barren measures* correctly describes the group as a whole, from the paucity of coal they contain, the two Washington coals, occurring only about 10–20 feet apart, are in places quite important. In this county the upper (called the *Washington bed*) is 10 thick, separated by 12′ of laminated sandstone from the lower (*Little Washington* bed) only 1′ thick.

As the *Upper Washington* limestone No. VI has been chosen by past observers in this part of the field, to mark the dividing line between the two groups of the Upper Barren series, the following clear and faithful description of its characterictics is reproduced from Rep. K. p. 45.

"In all portions it weathers to an *almost snowy whiteness* with the slightest tinge of blue. The upper part is quite slaty and is blue on the freshly exposed surface. The middle layers are dark, almost black, and frequently mottled with drab. They are exceedingly brittle, ring sharply when struck, and yield a limestone of superior quality.

"The brittleness of this portion and its ability to withstand the weather, fit it admirably for use on roads, and it is extensively employed in macadamizing the National road. The lower part is ordinarily of a light flesh color, and in point of purity is scarcely inferior to the middle portions. It is less brittle and yields more readily to the weather. The top and bottom divisions are persistent, but the *middle or dark portion* disappears soon after entering Greene county.

"The greatest thickness of this rock is seen in Washington county on Cemetery hill, near the borough of Washington, where it is a mass of shale and limestone, 30 feet 3 inches thick, sub-divided as follows:

Limestone laminated argillaceous,	2 feet.	
Dark shale,	5 "	
Calcareous shale,	6 "	
Shale with vegetable markings,	2 "	
Limestone,		10 inches.
Bituminous shale,		10 "
Limestone,	2 "	
Calcareous shale,	1 "	3 "
Limestone,	1 "	6 "
Shale,		10 "
Limestone,	3 "	
Shale,	2 "	
Limestone,	3 "	

"At the tunnel on the Hempfield extension, about one mile east from Washington, this bed shows nearly 20 feet of solid limestone.

In Washington county it is well exposed in Smith, Mt. Pleasant, Cross Creek, Donegal, Buffalo, Canton, Cecil, Franklin (North and South) Strabane, Somerset, Amwell, Bethlehem, Morris, and East and West Finley townships, and is occasionally seen in Nottingham and Peters. Its thickness varies from six to thirty feet, being greatest in the central portions of the county, and the interval between it and the *Washington coal* below varies from 100 feet on the State road in southern Smith, to 180 feet on Ten-Mile creek in Amwell township."

"At from 20 to 75 feet below this limestone there is an important coal bed usually found wherever its horizon is reached, called the *Jolleytown bed* wedged in between a shaly sandstone on top and a more massive one below.

Limestone (Middle Washington) No. 10 is a massive ferruginous, buff-colored stone, found wherever the No. VI limestone is reached, 40′ ± beneath the Jolleytown coal.

Beneath this comes 60′ ± of sandstone and shale to the *Limestone* No. III, usually thin in Washington and apt to be associated with the top layers of ———

Limestone (Lower Washington) *No. II*, from which it is usually separated by about 20′ of sandstone and shale. The latter stratum is quite important, as it everywhere accompanies the *Washington coal bed*, occurring immediately beneath it.

This *Washington coal* becomes of more economical importance in this county than anywhere else. It is however very variable. Its most northern exposure is at Eldersville in Jefferson township, overlooking the Pan-Handle railroad. Its thickness varies from 6″ to 11′.

This bed is mined in Amwell, Morris, Donegal, Buffalo, Canton, Franklin and South Strabane, and is of workable thickness at several localities in Jefferson, Hopewell, Independence and Mt. Pleasant townships. In this region it is apparently as important as the *Waynesburg* is in Greene county, and there are many points of similarity in the structure of the two beds. Each is badly broken up by thick clay partings, which render mining inconvenient and somewhat expensive.

The excessive variation of the bed renders its measurement at each exposure almost necessary. But its *ordinary* structure is quite simple and varies slightly from the following:

Coal,	1′	10′ 8″;
Clay,	3′ 7′	
Coal,	11″	
Clay,	4′ 6″	
Coal,	8″	

three benches of coal separated by two clay slates.

The *Washington sandstone*, 12′ thick, separates this coal from the *Little Washington coal bed*, thin and frequently grading into a black or gray shale..

"This coal was seen in West Bethlehem, Somerset, North and South Strabane, Franklin, Amwell, Buffalo, Donegal, and the northern portion of West Finley, and is from six to fourteen inches thick. It is not even approximately parallel to the *Washington Coal*, but invariably describes short waves, two to three feet deep andsix to thirty feet long. In these irregularities the upper bed does not participate, and all variations are at the expense of the intervening rocks." (Rep. K., page 54).

Beneath this coal is some shale and impure limestone, quite persistent in this county and resting on the *Waynesburg (B.) coal bed*, a thin and worthless bed, commercially speaking and frequently grading into shale. About 30′ ± of sandstone intervenes to another Limestone (1 a) frequently a calcareous shale in Washington county and always thin.

Waynesburg (A) coal bed, the bottom coal of this series, is everywhere persistent, where reached, except in the extreme north-west part of Washington Co., south of the Panhandle R. R. It is rarely more than 2′ thick, and separated by some argillaceous shale from the *Waynesburg sandstone*, or bottom member of the Upper Barren Series.

Space has been given to a repetition of the Upper Barren Measures in part, for it practically dismisses the best part of sixteen townships from a discussion of the Pittsburgh coal region.

Monongahela river (Upper Productive) measures.

This important series need not be rehearsed in detail, for it has been largely dwelt upon in the consideration of the geology of Allegheny county. Still, this series is almost as variable as the one just disposed of, and the upper portion of it is but rarely caught in the highest hills of Allegheny. Some of its coals too attain importance here which they lack further north.

It contains, in all, five coal beds in a thickness of something like 475′ of rocks.

The top one is the *Waynesburg Main coal bed*—a double or triple bench bed, and quite insignificant in this county—its extremes of thickness being 6″ and 7′. Its typical form, as exhibited at Pin-Hook, in Amwell twp. shows:

Coal,	5″ to 16″
Clay,	10″ to 18″
Coal,	27″ to 34″
Clay,	4″ to 20″
Coal,	5″ to 7″

But sometimes it is terribly cut up by small slate partings. Its interval above the Pittsburgh coal bed at the base of this series, may be conveniently taken at 375′, though of course subject to variations in different parts of the field.

The *Uniontown coal* is the next lower bed, resting immediately upon the Upper Division of the Great Limestone and therefore a useful guide to its location.

It is entirely unimportant *as a coal bed* here, and occurs usually as a bituminous shale, with a cannel-like fracture. Its interval above the Pittsburgh bed may be set at 275′ or in round numbers, 100′ beneath the Waynesburg.

The Sewickley bed is the third coal of the group ; quite important and available in Greene, but too thin to be of any importance here or in Allegheny.

At lock No. 5, on the river, it is 3′ thick, and at Brownsville it shows :

Coal,	3′ 6″	4′ 4″
Clay,	2′	
Coal,	8″	

Further north it becomes merely bituminous shale, as at Monongahela City. In the interior of the county, it is met with on Chartiers and Cross creeks ; but only as shale. It comes about 100′ above the Pittsburgh bed.

The *Redstone coal* is the fourth bed in descending order; always persistent, but seldom merchantable. It is largely a bituminous shale, sometimes carrying a few inches of coal, except at Monongahela City, where it attains the unusual development of 3′ 6″.

Its interval varies from 40 to 60 feet above the Pittsburgh, and though more usually the latter, an easily remembered interval would be the mean, or 50 feet.

The *Pittsburgh coal bed*, at the base of the series, needs no comment, as its exceptional excellence is well understood. It will be referred to in the township geology.

The prevailing features of interest in the Upper Productive Series lies in its limestone rocks.

Five distinct strata of limestone occur, two of them banded together, though usually separated into an Upper and Lower Division, by sandstone and shale.

These limestones aggregate about 100 feet in thickness, or more than one fifth of the entire group, and the double limestone is called the "Great Limestone." This great formation of limestone and shale spreads through an interval of 125 feet. The Uniontown coal rests upon it; the Sewickley coal is but a short distance below it.

Between the Sewickley and Redstone coals, the *Fishpot limestone* is from 10-20 feet thick, and *beneath* the Redstone coal there is another limestone 10′ thick.

Pittsburgh Series. (Old Barren Measures.)

Comparatively little need be said of this series, for only a limited portion of the upper part of them is exposed anywhere in Washington Co. Throughout the greater part of the county, these rocks are deeply buried.

Limited sections of them are obscurely exposed, beneath the Pittsburgh coal bed, along the Monongahela river; on Peters creek; along the Washington anticlinal south-west of Cannonsburg; along and north from the Pan-handle R. R.

Township Geology.

The 31 townships of Washington Co. are arranged with somewhat the following relation to each other, from north-west to south-east:

1. Hanover,
2. Robeson,
3. Smith,
4. Jefferson,
6. Mt. Pleasant, 7. Cecil,
5. Cross Creek,
13. Chartiers, 16. Peters,
19. Union,
8. Independence, 9. Hopewell,
14. N. Strabane, 17. Nottingham,
12. Canton,
20. Carroll,
15. S. Strabane, 18. Somerset, 21. Fallowfield,
10. Donegal, 11. Buffalo,
28. Allen.
24. Franklin, 29. W. Pike Run, 30. E. Pike Run.
23. E. Finley, 26. Amwell, 27. W. Bethlehem,
22. W. Finley, 25. Morris, 31. E. Bethlehem.

It has already been shown how local the only workable coal—the *Washington bed*—of the Upper Barren Series is; and therefore how needless it is to review a large part of Washington Co. *economically*.

And the same may be said of the Upper Productive Measure *coals*, outside of the Pittsburgh bed, which is exposed in East Bethlehem, East Pike Run, Allen, Fallowfield, Carroll and Union,—all essentially "river townships." Also to a very limited extent in Nottingham, along Peters creek.

In Chartiers, and sparingly in N. and S. Strabane along Chartiers creek; along the W. Virginia line on Cross creek; and finally in the Panhandle district, in portions of Cecil, Mt. Pleasant, Robeson, Smith and Hanover, this bed is also exposed.

Geology of Hanover, Smith and Robeson townships.

These three townships can be conveniently treated as one for they comprise, within their borders, nearly all of the outcrop of the Pittsburgh bed exposed in north-west Washington Co.

Robeson run forms the south-east border of Robeson twp. and separates it from Mt. Pleasant and Cecil.

Harmans creek bounds Hanover on the south, and divides it from Jefferson; while Smith township has a triangular shaped area extending south from the Panhandle R. R., bordering on Mt. Pleasant and Cross Creek townships. The State of West Virginia joins the area under discussion on the west, with Beaver and Allegheny counties on the north and north-east.

Raccoon creek drains a large part of the district northward; Robeson and Harman's creeks limited portions on the east and west. The dividing ridge between the waters of Raccoon and Wheeling creeks passes almost north and south through western Smith and central Hanover.

The *Bulger anticlinal* passes through Bulger station, on the Panhandle, in eastern Smith, and on through Robeson to Allegheny Co. The synclinal west of it crosses the same railroad at Burgettstown, on a parallel course. The geological sections of rock exposures extend from 125′ above to 300′ feet below the Pittsburgh coal in Hanover; about the same in Robeson; and from 675′ above to 100′ below the Pittsburgh coal in Smith. In this township alone are the Upper Barren Measures exposed, the upper Washington limestone not being reached in the lower part. In Hanover and Robeson, the Great Limestone is the highest rock met with. Quite an area of the *Pittsburgh coal* and Upper Productive Measures occupies the high country towards the Beaver Co. line, with Florence as a central point.

On the road running north from Florence to Frankfort, the bed occupies a narrow strip on either side of the road.

So likewise on the Steubenville pike, between Florence and Paris, the crop extending to within a mile of the latter place. To the east and south, towards the Burgettstown synclinal, the area is much broader and more compact, extending to the Panhandle railroad.

Nearly everywhere else erosion has performed effective work in the north-west, though several small patches have been left for local use in the high hills north-west of Florence. Just across the county line this coal is mined by several persons for local use.

At *Frazier's opening*, the following section was obtained:

Roof division,		2′	0″	5′ 11″
Breast coal,	*Coal*,		9″	
	Clay,		2″	
	Coal,	1′	1″	
Bearing in *coal* and partings,			3′	
Brick and lower bottom *coal*,		1′	8″	

"The coal is quite free burning, contains comparatively little ash, and shows pyrites only near the top."

On the ridge road, from Frankfort to Paris, the coal is opened about 2 miles from the former place.

The rocks are rising rapidly to the north-west here, and the coal has but little cover.

The coal shows near school house No. 5, on the road leading from King's creek to the Steubenville pike, and on the pike is opened at the first fork west of Florence showing:

Sandstone,			3′ 10½″
Breast *coal*,	1′	10″	
Bearing in *coal* and parting,		4½″	
Brick *coal*,		10″	
Lower bottom *coal*,		10″	

There is no roof coal here, the sandstone lying directly on the lower division and cutting out the usual clay parting.

In a very high knob at Florence, the horizon of the *Waynesburg coal* is believed to exist.

The village is largely supplied from openings in the Pittsburgh bed on the pike, about half-a-mile east from Florence.

Here the section varies but little from the following:

Roof division,	1′	8″	3′ 6″
Breast *coal*,	1′	3″	
Bearing in *coal* and parting,		5¾″	
Brick *coal*,	1′	1″	
Parting,		2″	
Lower Bottom *coal*,		6″	

The parting between the two lower benches is rather unusual.

The map shows a detached area of Pittsburgh coal, lying north of a branch of Raccoon creek. The coal was formerly worked on it, above the saw mill.

The Florence coal area is also considerably opened in Smith township, south-east towards the railroad.

Right in the synclinal, just west from Burgettstown Sta. the coal is opened at *Whittaker's bank*, where the structure is quite remarkable, as the following section reproduced from Report K. p. 278 will show:

Pittsburgh coal, Whittaker bank,	*Coal*,		8″	7 9″
	Clay,		4″	
	Coal,	1′	0″	
	Clay,		4″	
	Coal,	1′	0″	
	Clay,		4″	
	Coal,		3″	
	Clay,		2″	
	Coal,	1′	9″	
	Coal and clay,		5″	
	Coal,	1′	6′	

The thin lower seams probably represent the Lower Division. A clay vein, six inches wide, creates considerable trouble for two and a half feet on either side of it, in disturbing the coal bed.

The measures rise north-west from here, but not quite so fast as the railroad, which rises more rapidly to the Dinsmore tunnel. From here it descends westward, so that the coal shows just above the track at the west end at about 1080′± A. T. rising to 30′ feet above the track at the end of the tunnel approach, owing partly to falling grade. The coal is exceedingly variable here and badly cut out in places by horsebacks and clay veins.

Raccoon creek forks at the railroad, just east of Burgettstown. On the east fork the Pittsburgh coal shows at about 1½ miles north of the Mt. Pleasant line.

An opening here, just above where the Burgettstown road leaves the stream shows the bed partially opened, with sandy shale 18 feet thick on top of the coal.

The *Sewickley coal* in this part of the county is only about 60′–70′ above the Pittsburgh bed, and occurs as a bituminous shale. The two divisions of the Great Limestone show on the summit on the Burgettstown road.

The Pittsburgh coal likewise shows at a number of places along the State road and around Burgettstown; but the bed shows no new features.

The road from Burgettstown to Eldersville shows blossoms of the *Waynesburg* and *Washington* coals near the summit along the Jefferson township line.

There is scarcely any of the Pittsburgh coal left in the northern half of Robeson township. Along the Washington county line, however, a long strip extends along high ground to join the outcrop along the Steubenville pike at North Star. There is quite an area of the coal in the southern portion of the township. For two miles north of the railroad it is sparingly opened, although its blossom shows on every road.

About 1 mile north-east from Bevington, the coal was mined by Mr. Wilson, at the head of Karr's run, and again one mile south of the Beaver line, near Raccoon creek, by Mr.

Bigger. This is the most northern outcrop of the Pittsburgh bed, and the following section of the Barren Measures beneath it is given in K, p. 272:

Pittsburgh coal bed,	10' 0''
Concealed,	160' 0''
Sandstone,	50' 0''
Shaly sandstone,	40' 0''
Bituminous shale,	10' 0''
Coal,	3' 7''
Sandstone and shale,	35' 0''
Crinoidal limestone,	4' 0''
Coal,	1' 4''
Concealed to creek,	25' 0''

"The crinoidal limestone has a greenish color, and is literally crowded with fragments of crinoids and brachiopod shells."

Cecil township borders on Allegheny county, between Robeson and Chartiers creeks, and east of Mt. Pleasant.

The developments along the Panhandle railroad are quite numerous. Just after entering from Allegheny, and a short distance below McDonald station, on the Cecil township side of the creek, the *Briar Hill mine* (Sauters & Patterson) is opened at 1030' A. T.

These works adjoin Rend's and the coal shows little variation at either place. The pit mouth is about 50' above the railroad. Though active (Aug. 21, 1886) very little information could be obtained at this mine. An old map in the office shows the front hill workings (now pretty well abandoned) to be laid off on the single entry system, a "straight entry" being driven on the face, from the pit mouth 1550' long to a rear crop in a ravine; and a main entry, at right angles to this, up along the outcrop; face entries 160 yards apart. The new workings lie still further west, and the new map shows them laid off on the double entry plans, the coal to be largely drained into the ravine south of McDonald station. The output (daily) varies from 300 to 400 tons; all carried by mule haulage. The total output in 1885 was 37,000 tons.

The *Jumbo mine* (T. B. Robbins) is about half a mile above McDonald's station, and still on the Cecil side of the creek. The pit is but a short distance from the railroad and at 1030′ A. T. A well arranged plant for handling coal has been erected here, and the work done is first class.

Coal cutting machines are used here, with man labor also, and an extensive wire-rope system.

Bearing-in is done on top of the limestone, thus taking out the whole bed. The coal is said to average 4′ 6″, being 4′ 10″ at the pit mouth, and 4′ 2″ at the head of the tunnel. Along this main tunnel, driven S. 25° W. for 2600′, the coal dips, and is 22′ lower at the rear end than at the pit mouth, although some of the front coal is drained northwards. The coal looks exceedingly well here and the output (Aug. 26) was 500–600 tons. In 1885 this mine produced 31,500 tons.

So far as developed, all the coal has a block character, and a small slate, occurring about 4″ above the bottom, is frequently used for bearing-in by the hand laborer. The swamps met with are small.

The coal to the left (west) of the main entry is very flat, though draining to the main entry; while that lying to the right (east) of the main entry all dips south-west and south-east, and the water is pumped from a swamp in No. 7 entry. The front part of the mine is largely opened on single entry system; the rear workings are driven double.

The Jumbo mine has one of the best arranged plants in the region. Four pair of boilers furnish steam for all mine purposes, pumping and fan ventilation. They are 32′ long by 40″ diameter. There are 14 Harrison coal cutters in operation here (illustrated in chap. X), supplied by a single compressor, (Norwalk, Conn.) with a 20″ cylinder.

The original pressure to compressor and boilers is 80 lbs.; but there is a loss of 5 to 10 lbs. incurred in leading the air back into the working faces, due to friction and condensation, owing to the many curves in the supply pipe. The compressor carries two cylinders, high and low pressure, and two receivers; is almost without valve attachments and readily kept in order. The air from the intaking cylinder passes through a double pipe, water cooled, to the high pressure cylinder and thence to the receivers. The few valves are all well lined; work smoothly and regularly.

The wire rope haulage is effective. The attachment is made to the front car coming out, the train carrying a growler at the rear end. The rope is knocked off just after the train gets out of the pit and has passed over a knuckle on to the down grade track to tipple. The ingoing train moves by gravity, pulling the rope along with it.

These two last described mines are the only operations in Cecil township, and here, along its northern edge, is the only place the Pittsburgh bed outcrops. Everywhere else, to the south, it is deeply buried, the Upper Barren measures showing in summits on either side of Miller's run.

Mount Pleasant township, lying next west of Cecil, shows a somewhat similar geological section.

The Upper Barren measures occupy a considerable area in the central and south-west portion of the township, and the rock section extends upwards from the Pittsburgh bed along Robeson and Chartiers creeks to Limestone No. VI.

The *Waynesburg coal* is seen on the hill top in the village of Hickory, estimated 235′ above the Pittsburgh bed, the Claysville anticlinal passing just east of the village. This coal is also seen just west of Hickory, at the road forks. About 1½ miles W. S. W. of Hickory, at the Presbyterian church, the *Washington coal* outcrops, about 90′ above the Waynesburg coal.

Going north-west along the Burgettstown road, down a fork of Raccoon creek, the Waynesburg coal passes under water level on a north-west dip; but the Washington coal is seen on the road leading to Rankin's school house, about 3′ thick. The latter bed again shows below the school house, on the road leading down to the east fork of Raccoon creek, and the Upper Productive measures down to the *Uniontown coal*.

Along the Pan-handle railroad, a short distance west from Primrose, the *Pittsburgh coal* is mined on the south side of the track at the *Primrose mine* (T. B. Robbins) at 1050′ A. T. The pit mouth is located just beneath the public road, the coal being trestled across to the check house on the north side of the railroad. The coal at this mine is pretty well worked out, and dips generally southward.

The mine is opened on single entry system, its main entry leading S. 20° W. from the pit mouth for 2600 feet, and dipping all the way to an irregular water entry (No. 6 Butt) at 1010′ ± A. T. The water collects in a swamp on this entry about 600 feet west of the main gangway, from whence it is pumped to the surface.

The wire rope is carried in 1600 yards from the pit mouth, passes around a wheel laid under the track, and thence over sheaves in the centre of the parting track out to daylight again.

The roof division of the bed is not exposed in the mine, but in the rear workings the bed shows:

Breast *coal*,	2′ 9″ to 3′ 6″
Bearing-in *coal*,	4½″
Brick *coal*,	8″ to 1′ 3″
Lower bottom *coal*,	9″ to 1′ 6″

At present, bearing-in is done above the bands, and only occasionally is the brick coal found sufficiently clean to mine. The front coal was largely a block, open burning and semi-cannel in structure, and without separate benches. There was comparatively little of this coal however, and in the rear workings, clay veins and horse-backs are frequent. Output 175-200 tons a day, the total in 1885 reaching 28,904 tons. The coal crops at about the same level into Smith twp., opened at a country bank close to the Smith line at 1050′ A. T.

The Pittsburgh coal soon passes beneath water level further west along Robeson's creek, and is opened for the last time at the *Midway mine*, just below the station of that name. This company shaft to the coal at about 1050′ A. T., and their workings extend on both sides of the railroad. No information could be obtained here after three visits, except that the coal was a block coal, somewhat thicker on the south than north of the railroad, and yields from 3′ 6″ to 4 feet of coal. The bottom 1′ thick, is too impure to raise. The output in 1885, was 23,461 tons.

The *Pittsburgh coal* has a limited outcrop along Chartiers creek, just across the line of Chartiers township. The dip is south-east, away from the Claysville anticlinal.

Challenger's pit is further west, opened at the roadside on the Hickory road, at 1080′ A. T. It is quite possible that the coal is at water level here, and it is opened by a rock slope, descending N. 70° E. to the bed.

At Challenger's gas well, 200 yards further west, it is certainly beneath water level, and in a short distance, the *Redstone coal* appears on the roadside. The Pittsburgh coal hereabouts shows a variation in the lower division from 5′ 2″ to 6′ 2″, the breast coal being from 2′ 10″ to 3′ 6″ thick.

Chartiers township lies south of Cecil and Mt. Pleasant, with Chartiers creek for its eastern boundary, and the west fork of that creek flowing eastward through the centre of the township. It is along these two streams that the *Pittsburgh coal* is exposed, never much above water level. The *Waynesburg coal* shows in the extreme south-west corner.

The Washington anticlinal passes along the east side of the township and to its presence is due the extended outcrop of the Pittsburgh bed. Westward, along the west fork of Chartiers creek, the synclinal between the Washington and Claysville axis is not deep enough to bury the coal, which rises steadily into Mt. Pleasant township. All that portion of the Pittsburgh coal area, lying south-east of Chartiers creek, occurs in North and South Strabane townships, but will be treated of here as *geologically* a part of Chartiers.

The *Pittsburgh coal* is mined in the southern end of the township, along a small branch of Chartiers creek, and north-west from the railroad at *Marshall's mine* at about 973′ A. T. A short distance south-east from here the coal disappears beneath water level, and on the adjoining farm south-west it was struck at 42′ beneath the surface in McLean's gas well. The old Marshall pit is situated a little nearer Chartiers creek, but is now abandoned. The present pit does quite an active country trade. The bed furnishes about 4½′ of very good coal; but the mine is swampy.

The face entries all show a rise north-east; but the butt entries are very much troubled and the coal warped and squeezed in places, making drainage bad.

The main entry is on end, about 75 yards long and is lower there than at the pit mouth, the present coal lying very flat. An extension of the workings westward will probably develop a rise in the coal towards the Washington anticlinal.

The coal outcrops in the hills west of the Pittsburgh and Washington pike for some distance below Ewing's station, as well as on the east side of the creek, but is nowhere opened. It crops on the pike just before reaching the first cross road below Ewing's station at 988′ A. T., and across the ravine is opened at *Allisons mine*, whose mine track crosses the pike just at the store, to the tipple on the Chartiers Valley railroad.

About 12,000 tons were produced here for the year ending Oct. 31, '84, and 20,000 tons for the year ending Dec. 31, '85. The pit is some little distance west from the pike at 1005′ A. T., and the general dip of the coal is north-west and south-west, although some distance in, the coal is rising north-west. The mine is opened on single entry system, entries 150 yards apart, and is ventilated by natural means.

A large portion of the product finds its way to the western market, some little going to the Washington coal yards.

The bed section varies somewhat at the mine, but is about as follows:

Roof *coal*,	1′ to 10″
Main clay parting,	2′ to 2″
Breast *coal*,	3′
Bearing in *coal*,	2″ to 5″
Brick *coal*,	1″
Bottom *coal*,	1′

The yield averages about 4 feet of coal, the lower bottom not being mined. The coal is of excellent quality.

From this point the outcrop extends north-east in a pretty direct line to the hill facing the west fork of Chartiers creek, turning there north-west and extending without interruption up that stream into Mt. Pleasant township.

The first opening, on the south side of the hill, is the *Miller country pit* at 1020′ A. T. opened on the roadside south of Miller's house, and under light cover. The pit was idle and showed a few inches of roof coal, about 10″ of main clay parting, 3′ of breast coal, 2″ bearing in coal and about

1′ 6″ of brick and lower bottom mined out. The dip here is north-west.

The *Lesnitt country pit* is a little further up stream, on the north side of the McConnellsville road, opened in the orchard, back of Lesnitt's house at 1015′ A. T. Coal about 5′ thick.

The creek and coal crop run nearly east and west from here to McConnell's Mills and is next opened at *John Fees' country bank*, on south side of creek at 1000′ A. T. The main entry bears about S. 20°—25° W. and dips in that direction. The coal has a sandy shale roof. The roof coal is only 2″ thick; the breast varies from 30″ to 3′; brick coal 1′ to 1′ 2″ thick. Bearing-in is done above the bands, the slate being separated afterwards with the bearing-in coal. In a ravine running north from the creek here, the coal is opened on *T. Little's farm* at 1000′, just above the public road, and finally disappears on this branch at 1005′ A. T., rising north-westward.

France's bank is opened on the south side of creek, immediately back of McConnell's mills, at 1005′ A. T., the coal formerly being run directly to the mill. The mine was idle. The breast coal is reported 3′ 6″ to 3′ 8″ thick, 3″ of bearing-in and 1′ of brick, forming the mining portion.

The coal is still rising gradually north-west, but not quite so fast as the creek, and shows on the Hickory road at *Alexander McConnell's pit* 1005′ A. T., and opposite at *McCoy's pit* at about same elevation.

Malone's pits are a little further north-west, and but little above creek level at 1010′ A. T., and at the creek forks, *Cotton's pit* at 1030′ A. T., both idle and abandoned. The coal looks well here, but the breast is only 2½′ thick.

At many of these openings, the bottom limestone shows 4′ thick beneath the bed, separated from it by about 6′–8′ of clay shale.

Along the Hickory road, abandoned pits show at *Paxton's* 1050′ A. T. and a mile or so further west, on the south side of the road and about 20′ above creek level, at *John Meredith's pit* at 1075′ A. T. This is the last opening in Chartiers township. The coal looks very well. The main entry enters the coal on a S. 50° W. course and rises plainly going in, so that the mine is no doubt self-draining.

On another branch of the west fork of Chartiers creek, entering near Houstonville, the Pittsburgh bed is exposed for nearly 3 miles from the railroad, though lying quite level.

J. Thompson's pit is quite an extensive country bank, opened just north of Plum run, on the public road at 1015′ A. T. The main entry has a course of S. 70° E. and dips going in. The water is collected in a swamp in this entry and is pumped by means of a wind mill, located over the workings. The coal generally is of excellent quality, except in proximity to a clay vein struck in the mine, 2′–4′ thick and bearing nearly east and west, where the coal is sulphurous and slaty.

A section taken at the face of the present entry shows:

Sandstone roof,	9′	6″
Roof *coal*, good and regular,		10″
Main clay slate, variable,	2″ to 2′	0″
Breast *coal*,	3′	
Bearing-in *coal*,	0′	3″
Brick *coal*,	1′	6″
Lower Bottom *coal*, (not mined),	1′	

The output is from 20,000 to 25,000 bushels of lump coal a year.

A short distance further up Plum creek the coal is opened at *T. Thompson's bank* (idle) at 1015′, taking cover in a short distance north-west. Several other abandoned openings show along this creek in some of which the top sandstone lies directly on the mining coal, cutting out roof and main clay; at others the roof coal is present, but very thin.

Going down the main creek from Houstonville, the Pittsburgh coal is opened in a number of country banks.

On the west side, and west of the Washington pike, the *Houston pit* is opened at 1010′ A. T. and worked by Robert Thompson for his brick yard. Comparatively little coal is run out here, but it looks well and clean.

The lower division is a little over 5′ thick, say 63 inches; but the bottom coal 1′ to 1′ 2″ is not taken up. The brick coal is 1′ 2″ and the bearing-in coal 3″ thick. The breast coal shows some very thin slate bands occasionally and is from 32″ to 3′ thick. The roof coal is 2′± thick. To the north the coal is available on every farm, showing at an abandoned pit first at 1000′ A. T. and in next ravine along side public road at 995′ A. T.

Banfield's pit is opened further up this same ravine at 1000′ A. T. The coal here is practically the same as at Houston's pit. The Pittsburgh sandstone, immediately over the bed, is quarried to some extent for building purposes, on the opposite (north) side of ravine. One of the large Guffey Gas Wells is situated about 400 yards up this ravine, above the coal crop.

In the next hollow northward, and just outside of Cannonsburg, *Sherin's bank* is situated, at 980′ A. T., and 25 yards from the pike. This coal all goes to the country trade at 4c. a bushel. The character of this coal is most excellent and it must certainly make a handsome fuel. The main entry is on butts, and just at the pit mouth shows 32″ breast coal; 3″ bearing-in coal; 11″ brick coal and 1′ of lower bottom.

Just across the hill northward, the coal is reached by a slope at *White's bank* at about 960′ A. T. The opening is badly troubled with water and the coal could not be reached at all.

Within the limits of Cannonsburg, and on the east side of creek, the *Stoner mine* (Stoner & Co.) is opened close to water level at 945′. Though twice visited no information could be had here. The mine is opened on the single entry system, by a drift near water level, and the coal is said to dip south-east and *north-east!*

This mine produced about 24,000 tons in 1885, all shipped by railroad, and the bed is reported to show 2′ 6″ breast; 3″ parting; 10″ brick; 1′ bottom coal. The rear workings of this mine extend up to the ravine at Houston station, where, in N. Strabane twp. the coal shows on front of hill at 990′ A. T. and a little further up creek at another *Houston pit* at 985′. The dip is strongly south-east here and the coal disappears rapidly in that direction.

Cook's mine is the last opening on the Pittsburgh coal before its disappearance northwards on Chartiers creek. The opening is at Cannonsburg, just below Stoner's mine and at 935′ A. T. The output in 1885 reached 8,663 tons. The coal here is mined entirely for country use, and is just at creek level, dipping south-east. Good exposures of the roof shales and upper sandstone occur along the creek here and the Great Limestone shows in the railroad cut north towards the Allegheny line.

The Barren Measures, beneath the Pittsburgh coal, are exposed to a very limited extent along Chartiers creek and branches and at all places the exposures are unsatisfactory and obscure.

The *Great Limestone* and *Uniontown coal* are met with in many places in this township and occasionally the hills rise to catch the Waynesburg coal. The exposures of the Upper Productive measures however, are no less unsatisfactory than those of the Barren Measures, and in all instances, are economically unimportant. Along the West Virginia line, the Upper Productive measures are exposed on both sides of Cross creek extending for about 1½ miles up that stream from the State line.

Jefferson township, bordering the West Virginia line and bounded by Hanover, Cross Creek and Independence townships, shows a considerable outcrop of the *Pittsburgh coal bed* and Upper Productive measures, extending partially into Cross Creek and Independence along branches of Cross creek.

Patches of the Upper Barrens are caught in summits along the north-east portion of the township, extending the rock section exposed up to the Middle Washington Limestone; while along Cross creek the Barren measures show for 200 feet below the *Pittsburgh coal.*

The openings in the Pittsburgh coal were mostly closed. Along the bluff overlooking Harman's creek the *Washington coal* lies only 216′ above the Pittsburgh coal, and about 50′ above the *Waynesburg*. This is the most northern exposure of the *Washington* in the county and district; and the most northern locality where the *Waynesburg* coal is *known* to exist.

In the ravine north from Eldersville, the Pittsburg coal shows as follows:

Sandstone,	4′ 0″	3′ 0″
Clay,	1 0″	5′ 0″
Coal,	0″ to 0′ 5″	0′ 0″
Clay,	0″ to 1′ 0″	0′ 0″
Breast *coal,*	2′ 9″	2′ 8″
Bearing-in *coal* and partings,	3¾″	5½″
Brick *coal,*	1′ 0″	1′ 1″
Parting,	0″	½″
Lower bottom *coal,*	1′ 2″	1′ 2″

"The roof division is very irregular, and is frequently cut out by sandstone horsebacks, which however, rarely affect the lower division."

Another opening occurs on the road south from Hanlin station, 135′ above the track and 1080′ ± A. T., dipping strongly south-east into the Burgettstown synclinal.

About midway between Bethel church (close on the *Waynesburg coal*) and Gillespie's mill, on a branch of Cross creek, the Pittsburgh coal is exposed, and again on the east fork of the stream, 1½ miles above the mill. On the west fork the first openings are within two miles of Eldersville, and the coal is in sight along the stream for nearly a mile.

On Cross creek the coal is worked by Mr. Plummer, near the south-west corner of Cross creek township, and by Mr. Bushfield nearly a mile further up.

The measurements at these two banks (K. p. 285,) show:

Roof division,	Concealed.	Concealed.
Breast coal,	2′ 7″	2′ 8″
Bearing-in coal,	3″	4″
Brick and lower bottom coal,	1′ 10″	2′ 2″

The coal goes under cover on this stream near here at Jones' bank, where the roof is wanting, and dips south-east. The same bed is mined by Mr. Magee, about 1 mile from Independence on McGuire's run; also by Mr. Bell. At these banks the coal shows about 2′ 9″ of breast coal; 3″ of bearing-in coal, and 1′ 10″ of brick and lower bottom. The coal is 240′ above Cross creek at the mouth of McGuires run, but its rapid south-east dip soon brings it down in ascending the creek, where it is opened by every farmer, with a section about as follows: Roof coal 2′ 6″ to 3′ 4″;

Main clay 3″ to 1′ 4″; lower division coal and partings 4′ 10″ to 5′

Pittsburgh coal in the Monongahela river townships.

Passing now over to the eastern portion of the county, the exposures of the Upper Productive measures with the *Pittsurgh coal* are almost continuous to the Greene Co. line.

Union township occupies the north-east corner of the county, bordering on the Allegheny and Monongahela rivers, with Peters and Nottingham townships on the west and Carroll township on the south.

Peters creek flows nearly through its centre, north-east, while Mingo creek divides it from Carroll on the south. The Murraysville anticlinal, if continued south-west, should pass directly through this township; but it has evidently expired along the Allegheny Co. line or extends but for a very short distance into this township between the river and Peters creek.

The Pin Hook axis lies in the N. W. corner, at the 12 Mile House, though it is also very indistinct in Peters township, where the *Pittsburgh coal* is deeply buried and undeveloped.

The *Upper Barren measures* are everywhere absent in Union township, having been eroded from the surface by reason of the north-east rise of the rocks.

The *Upper Productive measures* covers two thirds of the townships, extending as a wide strip north-eastward from Nottingham twp. between Peters creek and the Monongahela river.

The *Barren measures* are confined entirely to strips along those two water ways—the rock section of the township extending from about 100 feet below the *Pittsburgh bed* almost to the *Washington coal* of the Upper Productive measures.

Along Peters creek the *Pittsburgh coal* outcrops continuously from Allegheny Co. across the Nottingham line, where it narrows to a point and soon disappears beneath water level.

On the Allegheny Co. line, the outcrop is well above the creek, which flows in a narrow valley of the Barren measures, 100 feet lower down. To the south-west however, owing to the depression of the measures the coal gets lower, so that at Gastonville, it is opened at the *Gastonville mine* (Pittsburgh & Chicago Co.) or *Peter's creek, No. 1 mine*, about 30′ above the B. & O. R. R. track at 925′ A. T. This opening is on the Lytle farm, and the main entry is quartered on the coal which apparently dips S. E. This mine was entirely idle, though twice visited in 1885. Its output in that year was nearly 25,000 tons.

Further west, along the creek, in the vicinity of Finleyville the Pittsburgh coal has been opened in a number of places. Finleyville station is about 914′ A. T.

Immediately south, in a small ravine heading up the Mingo road, *Murphy's pit* is opened at 917′ A. T., almost railroad level, and only about 200 yards from the creek. The coal is opened on a butt entry, draining northwards. The same coal is opened 100 yards *north* of the creek, at least 30 feet higher, showing an abnormal rate of rise towards the Pinhook axis, and indicating the presence of either a *fault*, running parallel to Peters creek, or else a deep *swamp* coursing northwest and southeast along the edge of the outcrop on the south side of the hill, and co-extensive with the well defined swamp traced through the Walton workings in Allegheny Co.

Going northwest up a branch stream from Finleyville, along the abandoned line of the Pittsburgh Southern railroad, the coal is steadily rising, and so continues for at least 2 miles to beyond the point the Pinhook axis would strike if continued to this point.

The *Pin-Hook anticlinal* therefore, has either died away altogether before reaching this creek or it has been shifted somewhat. The former view is the more probable, for the arch is next seen faintly, in a pretty direct line, in the south-east corner of Peters twp. near Thomas' saw-mill, and thence through Nottingham to Mr. Leyda's residence on Mingo creek.

The *Legler mine* is located on the west side of this stream, about ¾ miles from Finleyville, and is connected with the B. &

O. R. R. by means of the old Pittsburgh Southern track. The pit mouth is about 1004′ A. T. and 20′ above the track. The coal mined here was run to the Western markets; but recently the mine has not been very active. It is opened on the single entry system and the coal dips south-east. A new opening (Legler No. 2) has recently been made by this company, a few hundred yards above No. 1, and the combined output of the two mines for 1885 amounted to about 45,600 tons. A section of the lower division coal in this part of the region shows:

Breast *coal*,	3′	0″
Bearing-in *coal*,		4″
Brick *coal*,	1	0
Lower bottom *coal*,	1	6″

The country hereabouts is largely cut up by ravines, giving rise to a good deal of red coal.

The *Redstone coal* bed shows on the Brownsville road, a short distance above the Legler mine, at 1090′ A. T.

A mile further up this branch stream, the Pittsburgh coal is opened at *McGowan's pit* 1028′ A. T., and 200 yards further on at *Boyer's pit* 1038′ A. T., both idle and small openings.

The coal goes under cover a short distance above the latter, and on the Library road, at the summit, there is a fine exposure of the Great Limestone in an abandoned railroad cut at about 1100′ A. T.

West of Finleyville, the coal is opened on south side of creek at *Finley's country pit* 970′ A. T. where it shows:

Breast *coal*,	3′	2″
Bearing-in *coal*,		4″
Brick *coal*,	1	2″
Lower bottom *coal*,	1′	4″

The lower bottom coal is not mined here. The roof division is over five feet thick, and shows four benches of coal. Dip south-east. *Rankin's country pit* is close by, and near the Nottingham twp. line at 964′ A. T. This pit was idle, and shows about the same section of coal. In Nottingham twp. the coal outcrops along Peters creek for a little over a mile from the Union line.

It heads a short distance up the Mingo road, and is first opened, on the south side of the creek at the *Nottingham No. 1 mine* at 969′ A. T. This mine had just been opened when visited (Aug. 20, '85) and showed:

Breast coal,	3″
Bearing-in coal,	5″
Brick coal,	1′ 3″
Lower bottom coal,	1′ 4″

The main entry was about 9° off butts.

Nottingham No. 2 mine, of the same company, was also just being opened up, about 1500′ further west and at 978′ A. T. During the present year (1886), these mines have a working capacity of about 100 tons; but though applied for, no information could be gotten from the owners as to actual production, extent of mine workings or special features in the mines.

In the next ravine west from these openings, the coal is opened at *Phillips' country pit*, 981′ A. T. Here the character of the coal seen was most excellent; unusually so for this region. The coal breaks out in large slips, firm, bright and very clean, and the lower division measures about 5′ 8″. The lower bottom alone is not removed. All the rest makes a superior smithing coal. At Casseber's place however, but a short distance beyond, the character of the coal changes seriously for the worse, and considerable iron pyrites occurs in both the breast and brick coal benches. The coal goes under water level here, just after passing Thomas' saw-mill.

On the *Peters township* side of the creek, the coal is opened at the *Venetia mine* at Anderson station B. & O. R. R., just opposite Phillips' pit at 969′ A. T.

This mine was opened up in 1880—and has continued to run at intervals ever since. It was idle in Aug. '85 when visited, though that year some 12,000 tons were run out to the railroad for western trade.

The mine was opened on double entry system. The coal looks handsomely, as at Phillip's, and bears a high reputation. The *upper division* here is about 4½′ thick; the *main clay parting* 1′ and the *lower division* about 6′ of which the breast coal measures 3′ 4″; bearing-in 3″; brick coal 1′ and lower bottom 1′ 5″.

The *Lockhart mine* (Peters Creek Gas-Coal and Coke Company) is just below the Venetia mine at 984′ A. T. This mine was also closed, and since its opening two years ago, has had a precarious existence, owing to the large amount of red coal met with in the front workings. The coal is rising rapidly north-west here, and when once the workings are extended beyond the sloping hill side of light and pervious cover, the quality will undoubtedly improve.

The breast coal here measured 3′ 6″ thick, the remaining members of the lower division footing up about 2′ 4″.

Mention must be made of the excellent quality of the limestone occurring beneath the Pittsburgh coal bed along Peters creek. It shows about 8′ thick, quite persistent, and is quarried at Clark's above Finleyville and at the covered bridge near Gastonville. It is very pure, makes an excellent furnace flux and the clay resulting from its decomposition is said to make a serviceable pottery clay. It is dove colored, and without siliceous matter.

Along any of the roads leading from Peters creek over to Mingo creek and the river, in Union township, sections of the Upper Productive measures are passed over, in places reaching to the *Waynesburg "b" coal bed.*

Thus going south from Curryville, the *Waynesburg coal* is found about 250′ above the Pittsburgh bed, and the *Uniontown coal* is also exposed about 2′ thick, resting on the Great Limestone, which everywhere spreads through the hills in this part of the district.

On the road leading from Finleyville via the Mingo Presbyterian church to the river, the Great Limestone is first seen on the summit, 200 yards south-east of the cross roads to Cannonsburg at 970′ A. T., dipping rapidly south-east, and falling with the creek to Mingo church, where the *Uniontown coal shales* are seen resting on top of the upper division. Continuing down creek, the limestone shows for some distance, until the creek finally cuts through some sandy shales and exposes the *Sewickley coal* at 850′± A. T.

Further down stream, and about 400 yards from the main creek, the *Redstone coal* is opened at 835′ A. T. to supply the pumping engines of the Buffalo coal works located here. The coal is about 2½′ thick and slaty. The shaft to the *Pittsburgh coal* is 65′ deep.

This coal bed is exposed further down near the junction of the main creek at the covered bridge at 780′ A. T. and is dipping north-west into the Waynesburg synclinal.

Two country pits are opened in the Pittsburgh coal here at same elevation. The bed goes under water level just above there. Along the river, the openings in the township are numerous.

The Pittsburgh bed crops continuously from the Allegheny Co. line to Carroll township on the south ; for though the western division of the Waynesburg synclinal passes through Union township, meeting the river at Huston station, it is not deep enough to bury the Pittsburgh coal from view. The real centre line of the basin passes further south-east, through Monongahela City, but it is marked there by a subordinate anticlinal, which reverses the dip of the coal. Consequently all the measures dip north-west from Monongahela City to Huston station and rise again from the latter point towards Peters creek.

From Huston's run to the Allegheny line the river flows north-east and away from the synclinal. Consequently at each successive opening the coal has a double rise, *north-east* along a line parallel to the axis and *south-east* away from the basin.

At the old *Cincinnati mine*, at Huston run, the coal is about 742′ A. T.; Coal Bluffs 771′; Cleff 800′; Banner No. 1, 816′; Banner No. 2, 824′ and Hilldale 869′ A. T.

In the Hilldale mine the coal dips pretty constantly to the south-west. In the Banner No. 1 mine, the main entry is driven single through the first hill 400 yards and rises slightly north-west to 816′ in the ravine. Crossing this hollow, two parallel entries are driven on the face N. 26¾° E. and rise 27 feet in 900 yards and then fall an equal amount in the next 50 yards to the bottom of a "swamp," possibly a portion of the synclinal basin.

In the *Cliff mine*, adjoining on the south-east, the coal dips along the main entry, driven north, for 867 yards, meeting there the same swamp (or synclinal?) mentioned in the Banner mine, entering here on a course of S. 65° W., 200 yards wide and 18 feet deep.

If this serious and extensive swamp be really associated in this case with the Waynesburg synclinal, it confirms the view taken in the preliminary report of '85, that there is no regularity in form or position or course to be expected in the various synclinal basins of the district, and consequently their location cannot be known in advance without expensive and systematic testing, based upon an accurate mapping and levelling of all neighboring underground workings.

The Cliff mines' main entry extends much further beyond the "swamp," towards Lobbs run and the Allegheny line, and is graded for a uniform rise, amounting to $41\frac{67}{100}$ feet to entry No. 19, 1,563 yards from the river pit.

The butt entries, to the west of the main entry, all dip south-west. Horse-backs are frequently met with in this mine, in the main clay parting, and render the thickness of that member and the overlying roof coal members quite variable. But *clay veins* and *spars* through the lower division are conspicuously rare.

In the *Coal Bluff mine*, the main double entry, driven N. 20° W. rises 66 feet in 1,720 yards, and at the property line, at the end of Nos. 13 and 14 butt entries, 9000′ from pit mouth, the coal is at 863′ A. T. or 92′ above the pit mouth.

The swamp, which enters from the Cliff mine on a S. 65° W. course, does not cross the main entry; but approaching it quite closely, it suddenly takes a goose-necked turn abruptly northwards, and crosses No. 16 butt entry at about 520 yards east of the main entry and is 25 feet deep. When visited in Aug. 1885, none of the workings had been extended northwards sufficiently to cut this swamp again, most of the present mining being carried on in the new part, to the west of the main entry.

The swamp is supposed to continue its course northwards for some distance, and by some it is carried up nearly to Peters creek, before taking again its south-west course, and thus accounting for the marked differences of level in the coal on opposite sides of Peters creek.

So far there are no developments to prove or disprove this theory; though indications point to a very great irregularity in the position of the coal bed between Peters creek and the river. This state of affairs is somewhat accounted for by the sinking of the Murraysville axis, along the Allegheny Co. line, but is as yet wholly tentative to more extensive developments. It is here estimated that the coal rises north-west 26′ in 2,200′; it then remains nearly level for 1000′ and again rises 9′ in 500′ (Aug. '85). An incline within the mine conveys the coal from the roll.

From Houston run, the river bends steadily southward to the Carroll twp. line, and as a consequence the coal is rising towards the Monongahela City sub-axis.

The new *Cincinnati*, *Garfield* and *Buffalo* mines, opened close together and just before the river bends, show but little variation in level, being respectively 757′, 755′ and 753′ A. T. But at the *Courtney mine*, opened about ½ a mile north from the Carroll line, the coal has raisen to 774′ A. T. The *New Cincinnati mine* workings extend back to a branch of Mingo creek where, at the parsonage, a shaft 208 feet deep reaches a swamp, about 260 yards west of main entry. The mine is operated on the double entry system.

The *Buffalo mine* is an extensive development adjoining the last on the south, running out 58,000 tons during 1885 though largely idle that season, owing to strikes in the region.

The main entry is over a mile in length; but the coal is still hauled from the mine by mule power. The product of the mine is reported to yield 66% lump, 17% nut and 17% dust coal.

The *Garfield mine*, next south, is in many respects quite similar. Its main entry bears S. 13° W. and crosses a 14 foot swamp at 1,390 yards from the pit mouth. This swamp is a couple of hundred yards wide and is undoubtedly the same reported upon in Forward twp. at the Old Eagle mine (Annual Report 1885).

It is fairly possible too that this great swamp may be directly connected with the one followed through the eastern part of Union township, the latter being a tongue or offshoot of the main sub-basin. While these irregularities are everywhere recognized as such under the name of *swamps*, and are certainly fertile causes for disaster, it seems, in this particular locality, that to the rapid subsidence of the powerful Murraysville axis should be charged much of the widespread differences of level co-incident upon the blending together of the several sub-synclinals, elsewhere held apart by the presence of that axis. The structure of this immediate region is unique in the district.

Several old openings appear along the river bluff below the Garfield mine until the coal is again extensively mined at the *Courtney mine* at 774′ A. T. and above Courtney Sta. The main entry is driven on butts N. 65° W. until it meets the *swamp* and thence along the swamp S. 61° W. There seems to be no reason for not associating this swamp with the one developed at the Garfield mine. It is 25′ deep and 200 yards wide, and crosses the river about 150 yards, ± below the main pit mouth. This mine is operated on the double entry system and produced about 30,000 tons of lump coal in 1885, or about 66 per cent. of the total coal mined, 14 per cent. being nut coal and 20 per cent. dust.

There is comparatively little variation in the coal section at the various mines along the river in this township, providing measurements are made away from the swamps where the whole bed is generally somewhat swollen.

The usual or average bed section shown in seven of these mines is given below, for comparison, in tabular form:

		Hilldale.	Banner No. 1.	Cliff.	New Coal Bluff.	Buffalo.	Garfield.	Courtney.
	Upper Division, .	3′ 3″	3′ 8″	3′-4′	4′	4′—5′	4′ 6″	2′ 6″
	Main Clay Parting,	8″	10″	6″-8″	6″-10″	10″	10″	1′ 0″
Lower Div.	Breast Coal, .	3′ 0″	2′ 10″	2′ 10″-3′ 0	2′ 11″-3′ 2″	2′ 10″	2′ 10″	3′ 0″
	Bearing in Coal, . . .	4″	4″	4″	4″	3½″	3½″	4″
	Brick Coal and Partings, . .	1′ 2″	1′ 0″	1′ 1″	1′ 3″	1′ 3″	1′ 1″	1′ 0″
	Lower Bottom,	1′ 3″	1′ 4″	1′ 4″	1′ 0″	1′ 3″	1′ 0″	1′ 3″
	Average total thickness, . .	9′ 8″	10′ 0″	9′ 9″	10′ 3″	10′ 9″	10′ 6″	9′ 1″

The variations shown are quite apt to be merely local changes, and the irregularities are mainly confined to the roof members; therefore not affecting the mining portion of the bed. All of the roof coal carries some black slate and carbonaceous shale on top, throughout the series; but beyond being a characteristic feature of the *Pittsburgh coal bed*, no importance is to be attached to detailed measurements of these members.

The production of these mines in 1885, excepting Garfield, was 250,886 tons as follows: Hilldale 25,374; Banner Nos. 1 and 2, 38,817; Cleff 30,500; Coal Bluff 67,704; Buffalo 58,491; Courtney 30,000.

Carroll township has a long drawn out shape, extending east and west along the Monongahela river, south of Union, east of Nottingham and Somerset and north of Fallowfield.

The section of rocks exposed extends from 180 feet below to about 350 feet above the *Pittsburgh coal*, or up to the horizon of the Washington. The *Pittsburgh coal* has an uninterrupted exposure along the river front, and is everywhere accessible and largely opened.

The *Waynesburg axis* lies just outside the township, touching the river at Columbia, where but for erosion, the Pittsburgh coal would lie at 900 feet above tide on its crest. From here all the measures dip to the north-west.

At Monongahela City, the *Waynesburg synclinal* enters the township from Allegheny; but as the basin line is marked here by a subordinate anticlinal roll, the coal falls both ways from this point, into Union township on the north and to the Black Diamond mine on the south.

The Upper Productive coal measures are the surface rocks through seven-eighths of the township, a small patch of the Upper Barrens resting on the Fallowfield line east of Pigeon creek. On this ridge the *Waynesburg coal* has been opened in the past, reported 4 feet thick, capped with the Waynesburg sandstone. On the summit the *Washington coal* is reached, 140′ higher. The *Uniontown coal* can hardly be recognized in the township and it must be very thin.

In Scott's hollow, running up from Pigeon creek, the lower division of the Great Limestone is present at 55 feet above the *Redstone coal*, which is mined by Mr. Isaac Teeple, where it shows two benches 18″ and 21″ thick. The coal here is clean and in good shape, and has a good reputation for domestic purposes. The *Redstone coal* 3 to 4 feet thick is likewise opened about a mile below Lock No. 4.

Just above the Black Diamond mine, a stream enters the river from the south, upon which, half a mile from its mouth, the *Redstone coal* is opened in several places. The coal varies from 3′ to 3′ 6″ thick, and is clean and of good quality. The same coal appears in several other places through the township; is usually 40 to 50 feet above the Pittsburgh coal, and from 2 to 3½ feet thick. Near the mouth of Mingo creek, it shows an unusual development, being reported there, in an old air shaft, 4′ thick, overlaid by 10″ of clay, and this in turn by 2′ of coal and shale.

The *Pittsburgh coal* is of course largely opened, owing to its favorable position for attack.

The outcrop, entering from Union township, extends for over two miles up Mingo creek, which stream becomes the western township line about 1¼ miles from the river.

Below the covered bridge some 150 yards, on the road to Mingo church the coal is opened sparingly at *John Lofink's country pit* at 780′ A. T. and on opposite (west) side of the creek at *Cowan's bank* at 775′ A. T. The coal along this creek is dipping south-east. Both of these openings were closed and the coal could not be examined. Further down the creek and just back of the distillery is *Harrison's pit*, opened on the public road at 765′ A. T., where the roof coal is in three benches, in all 4′ 3″ thick and the lower division 4′ 9″ thick.

Gibson's pit at 770′ A. T. lies about midway between the two last mentioned openings, but on the *east* side of the creek. The lower division here is 5′ 2″ thick, of which the breast coal will measure 3′ to 3′ 2″.

The *Mingo mine* (T. Hutchinson) is opened on the river bluff, just beneath the river road and above the P. V. & C. R. R. track at 770 A. T.

This was quite an active operation at one time; but no coal has been run out for nearly 10 years, and the property has a very deserted aspect, although there is a large area of coal still remaining intact. No examination was possible here, so the following is taken from K.[4] page 79, as indicative of the condition of affairs in 1881–82.

"A *swamp* enters the mine from the west side, crosses the main entry at 65 yards from the pit mouth, where it is 4 feet deep; and passes through the workings in a semicircular manner, gradually growing deeper, until it connects with a circular basin 23 feet in depth and 192 yards in diameter. This happens at a point on the main entry 780 yards from the pit mouth.

"Another swamp enters this basin at its western side, opposite to where the first one enters.

"A third swamp, 7 feet in depth, connects with the basin on the south side and continues in a southerly direction through the mine, so far as developed."

It seems probable that the mines of this entire basin, as far south-east as the Westmoreland Co. line, will be more or less affected by such irregularities; and that such changes of level in the floor of the coal bed are directly associated with the formation of the basin lines, resulting in uneven settling of the bed, and all referred to the same primary cause. The coal near the pit mouth of the Mingo mine shows:

Roof division,		4′ 10″
Main clay parting,		0′ 10″
Lower division,		5′ 7″
Breast coal,	3′ 0″	
Bearing in coal,	0′ 4″	
Brick coal,	1′ 3″	
Lower Bottom coal,	1′ 0″	

The coal crop crosses the road, going east, just below the store, and is opened about 1200 yards from the Mingo works at the *New Eagle mine* (Campbell Bros.) at 786′ A. T. whose coal goes to the river trade. When visited in 1885, the main tunnel was in something over 700 yards, entering a swamp about 420 yards from pit mouth. The drainage is very faulty and innumerable troubles are caused by rolls in the floor of the mine, and which extend in all directions. Entries 7 and 9 both show swamps and dip towards the Mingo mine workings.

"A *fault* or break passes through the eastern side of the workings in an (approximately) north and south direction, throwing the coal down on that (east) side from 2 to 6 feet." K.^{4} 75.

The old mine was opened mostly on single entry, except No. 8 gangway, which was double, the latter system now prevailing. It was idle when visited in the fall of '85, but during that year its reported output amounted to 12,500 tons.

West from Monongahela City there were several abandoned openings in the *Pittsburgh coal*, one of which is the old *Dry Run mine* at 811′ A. T., within the city limits and on the east side of a ravine dividing the New Eagle coal.

This opening is close to the crest of the subordinate anticlinal before mentioned, and in addition to a dip up and down the river, this coal drains southward to Pigeon creek.

The mine is now only occasionally worked to supply the Monongahela City trade, and the lower division shows near pit mouth:

Main clay parting,		0′ 10″
Lower division,		5′ 5″
Breast *coal*,	2′ 10″	
Bearing in *coal*,	4″	
Brick *coal*,	1′ 0″	
Lower bottom *coal*,	1′ 3″	

The outcrop passes through Monongahela City, and extends some distance up the main stream and branches of Pigeon creek. The first opening seen is immediately behind J. Peters house at 790′ A. T., who can literally shovel coal from his pit into his kitchen.

Beneath the coal the limestone shows, underlaid by a sandstone, a small coal 8″ thick, and then 6′ of nodular limestone. At Peters the dip is south-east, the coal heading around a short ravine and rising to an opening of *Tullman and Canady*, on the public road at 798′ A. T.

It is opened here in two places, showing a very good quality of coal and with benches in lower division of 34″, 4″ and 18″, and again 36″, 4″, 14″ and 15″.

A country pit back of the race track shows coal at 803′ A. T., while *Dr. Van Voorhis pit*, north of the track, is opened at 788′ A. T. Following around the hill, the coal comes very close to the road near the dam at *Haywood's* old pit. About 100 yards further up stream is *Haywood's new pit*, at road level, at 758′ A. T., and dipping south-westward to above the bridge, finally opened at *Clinton Van Voorhis' pit* at 738′ A. T. Limestone shows in the creek just below the dam.

Scott's hollow heads up from Pigeon creek, east from the mill. It cuts out the Pittsburgh bed for a short distance and drains a part of the Catsburg mine through a rear opening (an air pit) at 758′ A. T. As the coal in this hollow all lies south-west from the river outcrop, the rise is quite marked going north-eastward along Pigeon creek to *Bolman's* and *Woodward's pits* at about 783′ and on the public road near the cemetery entrance at 785′ A. T. From here the coal dips up river to the Black Diamond works.

In the first ravine east of the cemetery it is opened at the *Catsburg mine* (Lewis Staib) at 778′ A. T. The main tunnel is on the coal face, and at 1200 yards in from pit mouth, No. 11 butt entry is driven north-west to daylight in Scott's hollow. At butt entry No. 2, 200 yards in, the elevation is the same as the pit mouth, a roll of 6 feet having been cut down between the two points. This face entry then fall slightly to No. 3 and rapidly to No. 4 butt, 460 yards in, and 27 feet lower than the front crop coal.

From No. 4 to No. 6 butt, 135 yards further, the whole fall is regained by a rise of 27 feet in the coal, and then from No. 6 to No. 11 butt entry a gradual fall south-west to the latter place, amounting in all to 30′. This point, No. 11 butt entry, is 1190 yards from pit mouth and at (778′—30′) 748′ A. T. or 10 feet lower than the rear opening in Scott's hollow. No. 11 butt entry, after rising 32 ± feet westward from the main gangway, falls abruptly into a swamp 19 feet deep. A pump is located on the knuckle, pumping all the water of the front part of the mine collecting in a swamp on the main gangway between Nos. 10 and 11, into this *swamp*. From here the water is again lifted 16′ by a pump placed on the west side of the swamp, and discharged into Scott's hollow, 19 feet lower.

These details have been given in order to show the excessive irregularity of the coal hereabouts, and the difficulties to be contended with in mining. The main tunnel was afterwards filled in between Nos. 2 and 6 butts to eliminate the fall of 27 feet in the swamp, a travelling way for coal from No. 4, being obtained by making the entry double. The mine was otherwise opened on the single entry system, and in each of the five main entries pillars 20 yards thick have been left to protect the travelling ways for back coal. The rear workings have been extended beyond Scott's hollow, which will probably have to be drained by a shaft and pumps. There is about 50 feet of surface there.

The deep 27 foot swamp mentioned as occurring at No. 4 butt, 460 yards in. comes in a circuitous pathway from the old mine workings to the west, and very probably has some connection with the 19 foot swamp crossing No. 11 butt. *East* of the main entry it crosses the centre entry at a point 160 yards from junction of No. 4 butt entry, and keeps fairly parallel until it crosses the line into the Ivile mine. The coal run out from this mine in 1885 to the river trade was 41,208 tons. An average section of the bed, *away* from the swamps, shows:

Roof division,		4′ 4″
Main clay parting,		10″
Lower division,		5′ 9″
Breast coal,	3′ 0″	
Bearing-in coal,	4″	
Brick coal,	1′ 2″	
Lower bottom coal,	1′ 3″	

The roof division has three main benches 18, 12, and 13 inches thick, carrying occasionally thin $\frac{1}{4}$ inch threads of slate, and divided more distinctly by two bands of clay 8 and 3 inches thick. The bed is capped by a carbonaceous shale and a higher slate, both of which partake, in great measure, of the cleavage joints of the coal.

The *Ivile mine* (Jas. Jones) adjoins Catsburg at 770′ A. T. This coal was taken mostly to the river tipple in 1885; but a slack track was laid along the hill side for about 100 yards, and used to dump into the railroad cars, if required. The mine was idle when visited; but the Catsburg *swamp* is reported crossing the main entry at 370 yards from the pit mouth, 30′ deep, and passes on eastward into the old Fort Pitt abandoned works. The coal section does not differ materially from Catsburg. Output in 1885 amounted to 37,240 tons.

The *Fort Pitt mine* is entirely idle, no great amount of work ever having been done there. Mr. Wall in K. 4, p. 67 says: "The head of the main entry and air course stands 620 yards from the pit mouth. They are driven *against the faces* or *perpendicular to the cleavage*, and parallel with each other, with 30 feet of a rib of solid coal left between them.

"A swamp enters the mine from the *Ivile mine*, crosses the main entry and air course at 330 yards from the pit mouth, and is drained in the mine by means of a syphon pipe."

The *Black Diamond mine* (W. H. Brown Sons), lies next east of the Fort Pitt, and is opened at 776′ A. T., not far from the railroad station, P. V. and C. R. R. which is 747′ A. T. This mine was opened on the double entry system, and as far as developed Sept. 1, '85, seemed to have escaped the trouble arising from the large swamp westward; unless one 11 feet deep in No. 4 Butt entry is to be associated with the former. The main entry and air course had been driven 1450 yds., with 30 feet of solid coal between butt entries. Drainage was mostly into the hollow north of the mine. From 1871 to 1878 the character of yield at this mine was as follows:

Lump coal, 67 per cent.; nut coal, 13 per cent.; dust coal, 20 per cent. The tonnage in 1885 was 39,000 tons and bed section about:

Roof division,		4′±
Main clay,		0′ 10″
Lower division,		5′ 8″
Breast coal,	3′ 2″	
Bearing-in coal,	4″	
Brick coal,	1′ 0″	
Lower bottom coal,	1′ 2″	

Robinson mine (S. B. Hayes), lies about ¾ miles east along river from Black Diamond and is opened at 790′ A. T. The coal from a point below Brown's works is rising steadily south-east to the Waynesburg axis.

The main entry is driven nearly south for over a thousand yards. No. 6 butt entry west, 430 yds in, is carried to daylight in a small ravine, and is run through a swamp all the way from the main gangway. The same swamp continues eastward into the Victory workings. The mine was entirely closed up in the fall of 1885; as was the *Victory mine* (Staib) adjoining at 784′ A. T. However, it is recorded that a swamp was met here also at 700 yards from the pit mouth, coursing nearly east and west. A ravine cuts out the coal east, before reaching the *Harlem mine pit* at 782′ A. T. (idle) and thence to the *Buzzard mine* at 790′ A. T., near Baird's station, and opposite the southward turn in the river.

Still further south and higher, around point of hill is the *Venture mine* (Crombie, Skillen & Co.) at 805′ A. T. which was just being fixed up for a "run" in the fall of 1885. It is a single entry mine, and a swamp is reported as occurring 500 yards in from pit mouth, near No. 7 entry. It takes a north-east course through the mine and leaves it at the east side of the workings, near the front of the property. It is 100 yards wide and from 21 to 25 feet deep. This is the last opening on the Pittsburgh coal in this township, the crop keeping around the river point and well back of Columbia to the Fallowfield line.

Fallowfield township lies next south of Carroll, facing eastward on the Monongahela river, and with Allen south of it. Pigeon creek crosses the western portion of the township and cuts off a narrow parallelogram of country extending north-west between Carroll and Somerset, to the border line of Nottingham. The rocks outcropping in Fallowfield belong almost exclusively to the Upper Productive measures.

Maple creek and smaller branch streams entering the river have cut down beneath the Pittsburgh bed, and limited sections of the Barren measures are exposed along these ravines. But elsewhere the next higher group of rocks spreads through the township, capped along the Carroll line and in the extreme south-west corner with a limited amount of the Upper Barrens. The rock section then extends from about 150 feet below the *Pittsburgh coal* up to the *Washington bed.*

The *Waynesburg axis* barely touches the extreme south-east corner, lying rather in Allen township; but as the effect of this axis north in Carroll township had already raised the *Pittsburgh coal* to a considerable elevation above the river, the south-westward increased strength of the anticlinal between Webster and Bellevernon has served to keep that bed at considerable elevations all along the river front in this township. There is not a single mining operation conducted on the Pittsburgh bed within the township limits, and but comparatively few country pits.

One such opening, about 1½ miles below Bellevernon, shows the coal at *Hugh McMahon's* bank at 898′ A. T.

The following section of the bed shows there, 160 feet above the river:

Bituminous shales,		10″
Ferriferous shale,	1′	0″
Coal, upper division,	1′	2″
Clay, main parting,		6″
Coal, lower division,	8′	9″

The *Pittsburgh coal* outcrops quite extensively on both forks of Maple creek, showing on the north fork at *Thos. Redd's bank,* where the following section is exposed:

Bituminous shale,		10″
Coal, roof divison,	3′	0″
Main clay parting,	1′	5″
Coal, lower division,	6′	1″

"At this opening little pyrites occurs in the upper bench of the lower division, but is abundantly present in the lower bottom, which is not mined. The 'brick' coal comes out in handsome blocks, but is much inferior to the upper bench. As a whole the coal is clean, and is said to be quite popular in the vicinity. At an opening on the adjoining farm the quality is the same. Just above Mr. Redd's house the *Redstone* is seen in the road, and at a short distance farther up the blossom of the *Sewickley* is exposed. The

Waynesburg was seen on the ridge near Withrow's blacksmith shop.

“Mr. Calvin, residing near school house No. 5, formerly opened the *Waynesburg bed* many years ago, and found it about four feet thick not including the upper bench, which he did not work. The *Washington coal* is seen on his property at one hundred and forty feet above the *Waynesburg*, and between the two beds the blossom of the *Waynesburg* “*a*” is exposed.

“In the greater portion of the township, that lying east from Pigeon creek, the exposures are very unsatisfactory. The *Pittsburgh coal* is available along the river border and the run separating Allen and Fallowfield, but on each of these lines openings are few. Elsewhere the land rises high and is so covered with *debris* that the *Waynesburg*, which is quite thin, is not often exposed even by its blossom. The strata dip rapidly toward the west, so that along the best line, that of the run referred to, the *Pittsburgh bed* passes under at a little distance above Bailey's mill.”

West of Pigeon creek, the *Waynesburg coal* is opened at Grable's bank, and on Saw Mill run, on south fork at Messrs. J. Warne and J. Hess, and on north fork at Mr. Stacher's. It shows three benches of coal, averaging about 1′, 2′ 8″ and 1′ separated by clay partings 1′ 2″ and 3′ thick.

In report K. p. 215 the following section of measures exposed between Stacher's opening on Saw Mill run and Pigeon creek is given:

1.	*Waynesburg Coal Bed,*	6′
2.	Concealed,	30′
3.	Limestone,	Fragments.
4.	Concealed,	40′
5.	*Massive sandstone,*	25′
6.	Shale,	10′
7.	Limestone and shale,	75′
8.	Shaly sandstone,	40′
9.	Limestone,	4′
10.	Shale,	30′
11.	*Redstone Coal Bed,*	1′

The Great Limestone shows rather more shale here than it does in the south-east portion of the county. The junction between it and the sandstone below is not fully exposed, but no evidence that the *Sewickley* is present was seen. The interval between the *Redstone* and *Waynesburg* is only two hundred and fifty feet, which is less than the interval between the *Waynesburg* and *Sewickley* in southern Greene county.

Allen township joins Fallowfield on the south and east, lying also east of East Pike Run township and occupying the big bend in the Monongahela river above Bellevernon.

The Upper Productive measures spread through three-fourths of this township with a broad band of the Barren Measures flanking the river and extending some distance (about 2 miles) south, up the south branch of Maple creek.

The *Pittsburgh bed* consequently outcrops continuously through this township, and the section extends some distance higher than the horizon of the *Waynesburg coal.*

The openings in the *Pittsburgh bed* are not numerous and are confined mainly to the southern portion of the township where the coal, now lying on the eastern side of the *Waynesburg anticlinal* is most readily opened up. However the bed is opened in various country pits on Maple creek, lying here too on the eastern side of the axis, and extending up the creek nearly to the Fallowfield line.

South along the Monongahela river the coal lies well above the river, until approaching Independence, it is opened at the *Clipper mine* (Clipper Coal Company) at 800′ A. T. or about 40 feet above the railroad track.

The coal from this mine is all conveyed across the Monongahela Division of the Penna. R. R. by an incline plane to the river tipple, and in the dull year ending Dec. 31, 1885, shipped 15,270 tons. There is a double drift opening here, the present main gangway lying 700 feet south of the former entry, and is driven south-west quartering the coal.

When the mine was visited a second time in July 1886, the company were preparing to close down permanently. The last run, prior to July 27, was 4000 bushels, although the mine is equipped to handle 8000 or 9000 bushels a day. The bearing-in was done on the bottom limestone, thus taking out the entire lower division of the coal, an unusual practice in this part of the region.

The section of the bed here, in the main gangway showed:

Roof division,		3′ 0″
Main clay parting,		10″
Lower division,		7′ 8″
Breast coal,	5′ 0″	
Bearing-in coal,	3″	
Brick coal,	1′ 0″	
Lower bottom coal,	1′ 5″	

The lower division however will not average over 7 to 7½ feet. The main breast occasionally thickens to 5′ 6″ and shows fine seams of slate through it. The mine is worked on the double entry system. An inspection of the maps of the company showed the present main tunnel driven on the face of the coal S. 25° W., and along this line 1,430 yards to the property line. The various butt entries are driven off this at N. 66°–67° W. to the right, and to the left south-east to daylight in a ravine heading up just below the railroad station.

All the coal along the main entry dips for the first 600 yards to a *swamp* which crosses it there on a N. W. and S. E. course, 10 to 15 feet deep and a couple of hundred yards wide. A water course is driven S. 43° E. for 300 yards approximately along this swamp almost to the crop line in the ravine, turning there south-west and intercepting left butts No. 11 and 12 before draining into the ravine.

The coal in the rear part of the mine all dips south-east. Clay veins and spars of considerable magnitude extend for long distances here, especially through the old mine workings. The coal is generally bright and brittle. There is a wire rope single-acting plane from the check house to the tipple, but none in the mine. The mine cars are run on to a "dummy" car and conveyed in a horizontal position to the tipple, one by one. The property consists of 258 acres of which about 125 acres had been mined out on July 27, '86.

John Biles country pit, abandoned, is directly back of the railroad station, and south of the Clipper Mine at 790′ A. T.

From Biles' opening, the outcrop swings south-west around the hill, curving with the river and keeping above the public road until below Luceyville station, the coal was opened at the *Brazendale & Co. mine*, where at the time of visit, the coal had not been more than faced.

The *Peacock mine* (Jonas Crothers) is a little further south-west, the outside mine track to the tipple leading across the public road on grade to the pit mouth at 761′ A. T.

This mine is worked on double entry system. The main entry and air course are driven on face northwards and rise slightly in that direction. The mine was idle during the strike of 1885, at which time it was visited, and no information could be obtained. The breast coal measured about 5 feet in the main entry; bearing-in coal and bands 4″ and the bottom benches 2′±.

The *American mine* (Washington Coal Co.) is a short distance west from the Peacock, and about $\frac{1}{8}$ mile below Woods Run station. The coal is opened beneath the public road at 783′ A. T. This was also idle for the same cause. It is worked on double entry plan, the main entry extending for over 1000 yards N. 13° E. and rises in that direction. The mine, when working, is quite an extensive one and in 1885 produced 26,407 tons.

West of Wood's run station, there are several openings developing the Pittsburgh bed to the East Pike Run township line.

The *Wood's Run mine* (W. H. Gregg) is the first of these opened in the point of the hill at about 785′ A. T. Double entry system is adopted here, with an air entry 20 yards from the main entry and parallel to it.

This mine together with others of this region, was idle during the fall of '85, and very little information was to be had. The main entry is reported to have entered a *swamp* in the second hill, about 600 yards distant from the second or rear pit mouth in Woods run.

A section of the lower division at this mine shows:

Main clay parting,		10″
Lower division,		7′ 11″
Breast coal,	5′ 0″	
Bearing-in coal and slate,	4″	
Brick coal,	1′ 3″	
Lower bottom coal,	1′ 4″	

In 1885, the reported output here was 15,028 tons.

The *Champion mine* (Morgan & Cunningham) joins the Gregg mine on the west. Elevation of coal at pit mouth 790′ A. T. The coal rises along main entry through first hill (500 yds) and as far as reported through the second hill, although a reversal of dip will probably take place here, where the Wood's run mine swamp is met with.

The mine opened on double entry system, and it has been the practice to take out all the coal except 6 inches of the lower bottom, which are left to improve an otherwise rolling and soft floor. In this way about 7 feet of coal are mined, counting about 1 foot of bottom coal. *Clay veins* and *spars* are rare.

The *Caledonia mine* (T. J. Wood) is the next extensive operation westward, opened at 795′ A. T. No mine measurements had been made here for 3 years prior to Sept. 1885, so that very little was known of the extent of the mine workings. Double-entry system is in vogue and all the left butt entries rise slightly towards the *Waynesburg anticlinal.* In K. 4, page 23, it is reported that "the rooms are driven 26 feet wide, and ribs between rooms are left 10 feet wide," which are not the usual dimensions adopted in this region. The entire lower division is mined out here, amounting to about 7½ feet, and yielding about 7 feet of coal. The floor is quite as much troubled as in the Champion mine, and some of the *rolls* are of serious extent. The output in 1885 was 37,690 tons.

The *Eclipse mine* (T. S. Neel) is the last and one of the most extensive operations in the township; opened at 790′ A. T. The public road is crossed by a trestle and the coal run to the river trade. The main tunnel is probably half-a-mile long, the coal rising north-west and north-east. The old entry is straight in on the face; the new entry turns off to the left, 75 yards in from pit mouth, and the new workings are all opened on double entry system. The breast coal is 4′ 6″ to 5′ 0″ thick; bearing-in 3″–6″ and about 1′ 6″ of the bottom coal is lifted. The output in 1885 amounted to 44,608 tons.

The Pittsburgh sandstone, above the pit mouth, consists of alternate layers of shale and sandstone, the former preponderating. All these mines in Allen township are in the Fourth Pool. At Mr. Noah Speer's grist mill on the south branch of Maple creek, and about 1 mile from the river at Bellevernon, the Pittsburgh coal shows: (K. 208)

Coal, 2 inches; clay, 1 foot; *coal,* 6 feet 10 inches.

"The disappearance of the roof division here is somewhat perplexing, since in the immediate neighborhood it is quite thick. The thinning cannot be accounted for by erosion, because the sandstone is separated from the coal by from seven to ten feet of clay shale. At this bank there are three partings in the middle of the lower division—a peculiarity of rare occurrence in this district, though it is characteristic of the bed in a large portion of Ohio. The coal is good throughout. On a road going due south from this mill the blossom of a thin coal was seen at one hundred and forty feet above the Pittsburgh.

"Opposite Bellevernon a fine deposit of glass sand was seen at one hundred and fifty feet above the river. It is of excellent quality and is largely used."

East Pike Run township occupies all that portion of the Monongahela river between the Allen south line and W. Brownsville. The northern part of the township extends west of Allen, with Fallowfield and West Pike Run on the north and west; while East Bethlehem township lies south of it.

Pike run cuts it nearly in two equal parts, entering the river between Greenfield and California. The rock section exposed extends from the *Pittsburgh coal* to 150 feet above the *Washington coal,* although the area of the Upper Barren measures is confined entirely to a single patch on the summit of Krepps hill, just west of W. Brownsville. This is one of the highest summits about here and as almost the entire Upper Productive series are exposed, capped with the lower portion of the *Washington Group,* the following interesting section of the series is copied from Report K., p. 201:

Sandstone,	40′
Limestone Middle Wash. No. IV,	Fragments.
Concealed,	100
Washington Coal bed,	Blossom.
Concealed,	130
Waynesburg sandstone,	30′
Waynesburg Coal bed,	3′ 6′′
Shale and sandstone,	45
Bituminous shale,	1′ 6′′
Limestone,	10
Shaly sandstone,	40′
Uniontown Coal bed,	3′
Limestone,	8′
Concealed,	70′
Limestone,	50
Sewickley Coal bed,	Blossom.
Shaly sandstone,	35′
Limestone,	25′
Concealed to river, *Pittsburgh Coal* at base,	65′

The outcrop of the *Pittsburgh coal* in this township is extensive and except above W. Brownsville where it sinks into the Lisbon basin at 700′± A. T. it is everywhere quite accessible. It is exposed continuously on Pike run to and across the West Pike Run township line, as well as on the numerous small branches of that stream.

Close to the Allen township line, it is opened at the *Dexter mine* (Crowthers, Musgrave & Co.) at 800′ A. T. This mine is now incorporated with the Globe mine property above it, and its coal is all run out there.

The *Globe mine* (Globe Coal Co.) lies about 300 yards west and the pit mouth is about 810′ A. T. The old part of the mine was opened on the single entry plan now changed to double entry. The main entry is driven on butts N. 67° W. 1,900 feet to the property line. Entries are turned off to right to meet those in the Dexter mine, the main entry of which is driven about half face and half end N. 15° E. All the west butt entries in these mines are rising steadily north-west, the main (butt) entry in the Globe raising 35 feet in 1,900 feet.

A detailed section of the Pittsburgh coal here gave :

Sandstone,	8′′
Shale,	2 0′′
Sandstone,	1′ 8′′
Shale,	2′ 0′′

	Sandstone,	0′	6″
	Carbonaceous shale,	2′	0″
Roof Division,	Bony coal,		2
	Slate,		1″
	Coal,		6″
	Slate,		2″
	Coal,		9″
	Main clay parting,	1′	0″
	Breast *coal,*	4′	6″
	Bearing-in *coal,*		3″
	Brick *coal,*		10″
	Lower bottom *coal,*	1′	4″

Bearing-in is done about 2″ above the floor. Production here in 1885 was 22,641 tons.

The river begins to make a sharp bend southward just above the Globe works, showing first the abandoned *Reed mine* at 790′ A. T. and next south the *Greenfield mine* (T. S. Neel) just north of the village of that name and at about 40′ above the river or 780′ A. T. This mine has pretty well exhausted all the coal between the river and the north fork of Pike run.

The water drains out of the river pit mouth rapidly and the rise of the coal north-west and north-east is quite marked.

The main entry is on butts, and shows an imperfect section at the pit mouth as follows:

Sandstone,		
Shales,	4′	
Roof *coal,*	1′	3″
Main clay parting,		11″
Breast coal,	5′	0″
Bearing in coal,		4″
Brick *coal,* seen,		8″+

The output in 1885 was 16,000 tons.

About a quarter of a mile below Greenfield, the following section of the measures between the *Pittsburgh* and *Uniontown* coals is seen. (Report K. p. 203)—

Uniontown coal bed,	3′
Limestone,	12′
Shale and sandstone,	28′
Limestone and shale,	88′
Shaly sandstone,	32′
Limestone,	30′
Sandstone and shale,	85′
Pittsburgh coal,	8′
Concealed to river,	48′

On Pike run, the openings are not very extensive; but the coal is plainly rising from the river at 780′ A. T. to the forks of the creek on the west at 840′ A. T.

Chalfant's country pit is the first at 752′ A. T.

Coal is exposed all along the road here and is opened at various places on both sides of the narrow valley. It is capped with about 25 feet of ferriferous shales.

The *Little Pittsburgh coal* crops near creek level, about 20 feet beneath the main bed.

The following account of the openings on Gorby's run, which were not visited, appears in K. page 204:

"Gorby's run enters Pike run at the village of Granville. On this stream the coal is in sight almost to the head, and rises from the river to where it disappears, nearly three hundred feet, the distance being hardly two miles. The openings are quite numerous on the west fork, and the coal goes under just above Mr. West's bank. On a bank of this fork the *Sewickley coal* is found at Mr. Smith's place, where it is three feet six inches, and is separated from the Great Limestone by four feet of shale. It is mined, by stripping, for use in burning lime, and seems to be a very fair coal. It is at two hundred and twenty feet below the exposure of the *Waynesburg*, on the Nottingham road, near the western line of the township. On the eastern fork of Gorby's run the *Pittsburgh coal* is mined by Mr. Duvall, and farther up by Mr. J. White. At the latter opening it shows:

Coal, 1 foot; clay, 1 foot 1 inch; *coal*, 6 feet 11 inches.

"The lower parting in the main division is two feet eight inches from the bottom of the bed. From Granville up Pike run the coal is seen almost constantly at about twenty-five feet above the stream, until near the township line it goes under, owing to a change in the course of the run."

About 1 mile up Pike run from the river, a new tipple was being erected (September 4, 1885), on south side of creek at *Michener's mine* 762′ A. T., but no coal had been run out.

The lower division coal through here is about 7′ 3″ thick, separated by 10 inches of roof coal, and by 8 inches of clay parting.

The *Smallwood pit* lies well up the hillside at the forks of the stream, near the bridge at 842′; but it may not be the Pittsburgh coal.

At the head of Lilly's run, entering the river a mile below W. Brownsville, the *Waynesburg coal* is mined by Mr. Lilly, showing:

Coal,		10″	3′ 7″
Clay,		3″	
Coal,	2′	6″	

It is slaty and sulphurous.

For two and a half miles below Brownsville, the Pittsburgh coal is pretty effectually buried in the river bottom, although it nearly reaches Brownsville, before passing beneath water level.

All the mines described in this township are within the limits of the Fourth Pool.

East Bethlehem township occupies the south-eastern corner of Washington Co., bordering the Greene Co. line, and fronting on the Monongahela river from West Brownsville to Millsborough, at the mouth of Ten-Mile creek.

It is a large township, and though practically undeveloped as yet, it will, from its geological position, command an important position when necessity or favor shall require the development of the upper pools along the river.

The *Lisbon synclinal*, after touching the river at Brownsville, extends directly south-west, in Fayette Co., and does not reach the river again until its great bend around Luzerne twp. of Fayette, entering Greene Co. not far from the mouth of Muddy run.

The *Pittsburgh coal* bed is just below water level at W. Brownsville (Pool level 738′; Pittsburgh coal 710′ A. T.) and for some distance above Lock No. 5, its level does not change much, owing to the course of the river being practically parallel to the synclinal axis. But turning westward the coal soon rises again from the river, and is exposed continuously from this point to the Greene county line. And as the *Waynesburg anticlinal* runs through the western portion of the township, crossing Ten-Mile creek at Hawkin's mill, all this river coal can be mined to the rise through fully half of the township.

The section of rocks exposed in the township extends from a little below the *Pittsburgh coal* to the Waynesburg sandstone.

The Upper Barren Measure rocks are confined to the highland along the National Pike, extending east nearly to Centreville along that road and township line and outcropping west around the headwaters of the various streams into W. Bethlehem township.

Another outlying patch of these measures shows east of the road leading from Lock No. 5 to Centreville.

The Upper Productive measures form the surface rocks throughout all the rest of the township, except along a narrow strip, beneath the *Pittsburgh coal* on the river.

The developments on the *Pittsburgh coal* are not extensive as yet.

The *Knob mine* (Knob Coal Company) is situated on the river bank, just south of West Brownsville. The coal is reached by a slope 190 feet in length, starting above the horizon of the *Redstone bed*, and reaches the coal in a vertical depth of 68 feet at 710′ A. T. The mine is opened on double-entry system, the main entry and air-course being driven 60 feet apart.

The *block system* of development prevails, the room entries being driven square against the butts and 90 yards apart. Sub-air-courses are driven parallel with the main entry and air-course, 90 yards from them and 90 yards from each other. The rooms are driven 24 feet wide; and the ribs between the rooms are left 9 feet wide, leaving 25 per cent. of the coal in the mine.

The main entry dips from the foot of the slope for 200 yards, rises 17 inches in the next 75 yards, dips 4 feet in 250 yards succeeding, then runs level for 25 yards and dips rapidly to its head. At a distance of 450 yards from the slope the coal is 20 feet lower or at 690′ A. T., and the coal also dips down river.

Most of these facts are taken from Report K.^{4} p., 10, the mine being idle when visited during the strike of 1885.

Lying close to, if not directly in the synclinal trough, these facts would tend to prove that the Lisbon basin, like many others in the region, has its axial line marked by an *anticlinal roll*, reversing the dip locally.

The average section reported by the superintendent gives:

"Soapstone" slate roof,		
Roof *coal*,		4″–10″
Clay slate parting,		6″–10″
Breast *coal*,	5′ 6″–6 6″	
Lower coal, left in,	2′	

Mr. Wall measured the following section in the mine:

Sandstone,	
Coal,	2′ 0″
Carbonaceous shale,	17′ 6′
Coal,	6″
Overclay,	1′ 0″
Breast *coal*,	5′ 9″ to 6′ 0″
Bearing in coal and bands,	4″
Brick *coal*,	1′ 2″
Parting,	½″
Bottom *coal*,	1′ 9″

This section shows a total thickness of 9′ to 9′ 3″ of which the breast coal *only* is taken out. The coal is a handsome, clean fuel, the output of the mine furnishing 66 per cent. lump, 17 per cent. nut, and 17 per cent. dust. In 1887 the total output reached 31,500 tons.

All the remaining operations on this bed in the township are merely country pits. The first of these is opened just around the first bend of the river at the *Black Hawk or Driftwood mine* at 762′ A. T. This is the first mine in Pool No. 5.

The coal mined here (breast and brick) is about 6½ feet thick, 2½ feet being left in for better drainage. The main clay and roof coal are each about 1 foot thick, the whole capped with 3′ of carbonaceous shale.

The coal dips slightly into the hill north-east, and is about 12 feet lower in 150 yards. This is owing to the fact that the *Waynesburg axis* becomes strong south-west from Brownsville, the reverse of what is usually the case. This rise however soon subsides.

The *Walkins bank* lies about ½ mile further north-west up the river, at 773′ A. T. It is only a small country pit and was not working; coal section about the same.

The *Maple Glenn bank* is another half mile up river, opened about 40 feet above pool level at 790′ A. T.

It was also idle, and at the pit mouth the coal was considerably squeezed by the massive sandstone roof which overlies the bed, and separated from it by only 1 foot of shale and 1′ 2″ of clay slate.

This Pittsburgh upper sandstone is a leading feature of the river bank further south, and is quite massive, 30′ to 40′ thick. The stone has a blue-gray color here, is micaceous and somewhat honeycombed near the top. It is quite extensively quarried for building stone.

Crouch's pit lies just beyond a small ravine, ¼ mile above Maple Glenn. The bottom of the bed is not well exposed but it is in all about 8′ thick. The roof coal shows about 10″; main clay 1′; and then 46″ to a small parting, beneath which there is 38″ exposed. The pit was abandoned, and is 805′ A. T.

The river runs nearly east and west for the next 1½ miles and the measures are nearly level.

Hancock's pit is the first opening at 835′ A. T., situated close to the mouth of Barney's run. South of this stream, the coal is again opened at the *Vandegrift pit* at 840′ A. T., from which coal has been dug for use in his mill and distillery.

The opening is close to the road, and shows the following section:

Sandstone roof,		
Roof *coal*,		10″
Main clay parting,	1′	0″
Breast *coal*,	3′	8″
Bearing in *coal*,		4″
Brick and bottom *coal*,	3′	4″

A mile further up river, on Fishpot run, the coal is opened at *Bear's pit*, on both sides of run at 835′ A. T., and near the old salt works. The Little Pittsburgh coal and limestone both show here at road level, and the main bed extends about ¼ mile up Fishpot run.

A bore hole put down here for salt started above the horizon of the Little Pittsburgh coal and struck the Morgantown SS. 42′ thick at about 130′; the top of the Mahoning SS. at 350 feet and the top of the Piedmont SS. at 530′ through which it passed for 74 feet to a total depth of 604 feet.

In a small ravine on the south side of the Bealsville road, *Register's and Martin's pits* are opened at 835′ A. T.

The coal exposed at the pit mouth is only 64 inches thick, capped with a massive sandstone which quite extensively cuts out the main clay and roof coal. Bearing-in is done about 3 to 4 inches from the bottom. The total thickness therefore is about 6 feet, although the bed hereabouts usually shows 8 feet of coal in all.

Quite a series of pits line the river for the next half a mile south, the first of which is the *Finnis St. Clair* at 840′ A. T. where the coal also shows 6′± thick, with main clay and roof coal cut out by a massive, gray feldspathic sandstone 30′ thick.

Weaver's pit is a short distance below Fredericktown where about 5′ of the limestone floor is taken up for drainage and about 70 inches of coal exposed beneath the main clay parting.

Back of the Fredericktown mill, the coal was formerly opened at 820′ and *Mrs. Phillip's pit* lies about midway between this and Millsborough, opened on the roadside at 810′ A. T. Here there is a sandstone roof, 6″ carbonaceous shale, 13″ roof coal, 1′ main clay, and 6′ 6″ of lower division coal.

The crop extends through the rear part of Millsborough, and half a mile up Ten-Mile creek.

On the river here the coal is just above water level, and the crop is honeycombed with short pits.

At the *Montgomery pit* the coal is at 755′ A. T. and shows 6″ roof coal, 6″ clay slate, and 6′ of lower division coal. The coal passes beneath water level and does not appear on the river again until after the Lisbon synclinal is crossed at Muddy run, as far south as Gray's distillery, above Whitely creek.

On the high hill above the mouth of Dog Hollow, entering Ten-Mile creek above Millsborough, the *Waynesburg* coal was once opened, and the following section of the Upper Productive measures reported in K. page 175:

1.	Waynesburg sandstone,	35'
2.	*Waynesburg Coal bed,*	5' 8''
3.	Concealed,	125'
4.	Sandstone,	10'
5.	Limestone,	80'
6.	Shale,	5'
7.	*Sewickley Coal bed,*	2'
8.	Sandstone,	40'
9.	Limestone,	25'
10.	Sandstone and shale,	25'
11.	*Redstone Coal bed,*	blossom.
12.	Sandstone,	50'
13.	*Pittsburgh Coal bed,*	7'
14.	Concealed,	12'

The *Waynesburg coal* is here in four benches, six, fourteen, nineteen and nine inches respectively. The coal is very poor, containing a good deal of sulphur and leaving much ash and cinder. It is opened by many of the farmers in this portion of the township, especially by those living on the ridge. Though very poor it is easily reached on the hilltops and is mined because of the difficulty of hauling coal from the river at Frederick or Millsborough. Between school-houses seven and eight, openings were seen belonging to Messrs Henry Brister, (1) A. Bowser, (2) E. Buckingham (3) and N. Barnard, (4) which gave the following measurements—

Waynesburg Coal.	(1)	(2)	(3)	(4)
1. Shale,	0' 0''	1' 2'	0' 2''	0' 0''
2. *Coal,*	0' 5''	0' 8''	0' 9''	0' 5''
3. Clay,	0' 3''	0' 5½''	0' 8''	0' 6''
4. *Coal,*	1' 4''	1' 3''	1' 4''	1' 6''
5. Clay,	1' 0''	0' 11''	1' 2''	1' 4''
6. *Coal,*	1' 6''	1' 8''	2' 5''	2' 0''
7. Clay,	0' 0½''	0' 0½''	0' 5''	0' 5''
8. *Coal,*	0' 8''	0' 10''	——	0' 3''

At Clarksville the *Sewickley coal* is 15 feet above the creek, and the *Great Limestone* extends up to the hill top in several layers of limestone interstratified with shale and sandstone.

On Plum creek, the *Waynesburg coal* has been opened in a number of places now deserted, taking cover at the old mill, about 2 miles up the run from Ten-Mile creek.

The coal carries about the same thickness according to report 5′ 8″, but cut up with clay bands as already described, and everywhere a dirty useless fuel, commercially considered. Very few country banks can mine this coal successfully.

Along the river at Millsborough, the *Redstone coal* shows 1′ thick at about 45′ over the Pittsburgh seam, and mostly shale. At Fredericktown the bed yields about 6 inches of coal in a mass of bituminous shale 6′ thick.

Two miles *below* Fishpot run both the *Redstone* and *Sewickley* beds are seen at intervals of 40 and 130 feet above the Pittsburgh, and between the beds, a mass of limestone 25 feet thick. A mile further down, on land of Elias Crouch, the same beds are exposed, with the Great Limestone showing on top 65 feet thick.

At Lock No. 5, a similar section shows, with the *Sewickley coal* 3 feet thick. It is again exposed, one mile from Brownsville, at Henry Howard's residence, in two benches 3′ 6″ and 0′ 8″ thick, separated by 2′ 0″ of shale, all capped with the Great Limestone on the National Pike. The *Waynesburg coal* shows just beyond Centreville, and was formerly opened on the properties of Messrs. Horton and Welsh.

One other exposure of the *Upper Productive measures*—hardly to be considered by reason of its inaccessibility at present—occurs at the village of Pin-Hook or Pleasantville, in Amwell twp. Here the top members of the group are brought up on the crest of the *Pin-Hook axis*, and the following measurements of the *Waynesburg coal*, largely opened there, appear in K., p. 186:

Wagnesburg Coal.	1.	2.	3.	4.	5.	6.	7.
1. *Coal*, . .	1′ 1″	2″-9″	1′ 4″- 11″	1′ 0″	1′ 0″	4″- 5″	1′ 0″
2. Clay, . . .	1′ 0″	1′ 2′	1′ 6″- 10″	1′ 0″	1′ 0″	1′ 2″-10″	1′ 0″
3. *Coal*, . .	3′ 0″	2 10″	2′ 7″-3′ 4″	3′ 2′	3′ 3″	2′ 10″	2′ 8″
4. Clay, . . .	6″	6″	2½″	3″	3″	?	?
5. *Coal*, . .	. . .	6″	5″	7″	6″	6″	. . .

CHAPTER VII.

Greene County.

Greene county has an area of 620 square miles. It occupies the extreme south-west corner of the State with Washington Co. on the north, the Monongahela river on the east, and the State of West Virginia bounding it on the remaining two sides.

But one railroad—the Washington and Waynesburg 28 miles long—enters this county, and that only extends to Waynesburg. Slack water navigation has not, as yet, been extended far enough up the Monongahela to entirely satisfy the wants of the eastern end of the county, although this want is being rapidly met by the construction of Dam No. 8, just above Dunkard creek.

At present the river is navigable as far south as Greensboro', except during very dry weather.

To a person approaching Greene Co. by water, a false impression of its topography is given by the bold and forbidding bluffs along the river hills. A short distance back, the abrupt bluffs give place to a gently rolling country, with high summits, but easy slopes.

Topography and geology have alike combined to make by far the larger part of this county, a fine agricultural district, which can be advantageously farmed. A glance at the coloring of the map tells the story. The structural characteristics of all these south-eastern counties have been referred to frequently, and the almost universal *sinking of the measures south-west* emphasized. Its effects in Greene Co. are as well marked as elsewhere.

In the central and northern part, where the Upper Barren measures (which make up five-sixths of the surface rocks) are mainly composed of limestone and soft sandstones and shales, the valleys are broad, and the country rolling. The same condition of things prevails immediately back from the river front, where the map shows the coloring of the Upper Productive measures. But in the southern part of the county, along Dunkard creek and its tributaries, and the head waters of Fish creek, Wheeling creek, and Ten-Mile creek, the Upper Barrens are made up largely of hard, resisting sandstones; but little shale and limestone exist; and as a consequence, the valleys are narrow and deep; the hills precipitous; and cultivation is almost entirely confined to the tops of the broad hills, where fine uplands exist.

The limited communication enjoyed with the outside world, has necessarily retarded the growth of Greene Co. For a considerable portion of the year water navigation is closed, and at best, only benefits the extreme eastern townships; while the larger part of the county has very little means of exchanging its commodities with any save its own immediate neighbors.

The main water-shed of the county is very distinct and simple, and lies well towards the western side. Fully four-fifths of the drainage is east and south-east into the Monongahela; the balance west and north-west into the Ohio river direct.

The principal streams entering the Monongahela river are:

1. *Dunkard creek*, rising in south-west Greene, and flowing eastward, alternately in West Virginia and Pennsylvania and draining almost the entire southern portion of the county, with the exception of Spring Hill township.

2. *Whitely creek*, though short in comparison to Dunkard, is of almost as much importance to the citizens of Greene Co., and drains a considerable area of the eastern portion of the county, north of Dunkard creek.

3. *Muddy run* lies next north, an inconsiderable stream, draining only Cumberland township.

4. *Ten-Mile creek*, branching three miles from the river, at Clarksville, into the North and South forks, and with its tributaries in this and Washington Co., making by far the most important stream entering the Monongahela river from the west.

The *South fork* drains the greater part of Greene Co., starting near Rodgersville, at the confluence of Gray's and McCourtney's forks. Brown's fork enters it just above Waynesburg and Smith's creek just below the capital, and before reaching the river its volume of water is still further increased by Ruff's creek.

The *North fork* lies almost wholly in Washington Co., making the county line for about three miles above Clarksville, which afterwards is marked by a high ridge between the two forks.

The highlands of south-western Greene mark the sources of several streams that become of importance on the Ohio slope. Such are Fish creek, a very rapid stream, and the two forks of Wheeling creek, meeting at Ryerson's station in Rich Hill township and draining Aleppo and most of Jackson and Rich Hill townships.

Surface Geology.

The former work of the survey in this district (See Report K.) traced the outlines of several distinct terraces along the Monongahela river and the streams entering it from the west, which demonstrates the former position of the river at different periods of erosion. The following brief account of the Greene Co. terraces will be found on page 11 and 12 of that report:

"At the mouth of Dunkard creek, at 180′ to 190′ above the stream, there is a well marked terrace which can be traced several miles up the creek. At some localities it shows a curious conglomerate, consisting of small pebbles and gravel, with some carbonaceous matter, the whole cemented by oxide of iron.

"At Greensboro', the terraces are wholly destroyed in outline by erosion; but the rounded and polished fragments continue in sight to 275′ above the river bed; thence up to 320 feet, the fragments are rare, but the soil is a river sand covered with red clay.

"Below Greensboro', the terraces are seen at 80, 120, 250, also 310 feet above the river bed. At the mouth of Whitely creek, the second one is very distinct; and it can be traced up the creek to Mapletown, where the dark conglomerate is seen. Rolled and polished stones are of large size and frequent occurrence on this stream. At the mouth of Muddy creek, there is a fine terrace at 260 feet above the river, which is continuous along the creek to beyond Carmichaels, where it forms a handsome plain on which that village stands. The soil there, at somewhat more than three miles from the river, is sand mixed with some clay, and contains vast numbers of rolled and polished stones, which are exposed by the plow in the fields, and by cuttings in the roads leading to the village. The deposit of sand and gravel is from fifteen to thirty feet deep, the thickness having been ascertained from the statements of well diggers. A precisely similar condition prevails on Pumpkin run, which enters the river at Rice's landing, three or four miles below the mouth of Muddy creek. There the upper terrace on the river hills is at 300 feet above low water mark, and extends back for about two miles and a half, being crossed near its edge by the road leading from Carmichaels to Millsborough. The fragments are numerous, polished and vary in diameter from one inch to two feet; most of them are oval, and they had all been subjected to much wear before they were finally deposited.

"At the mouth of Ten-Mile creek, the terraces are 20, 185 and 310 feet above the river. No pebbles of large size occur on the highest shelf, which is marked only by the sandy soil and the distinctly level surface. A still higher one is indicated by some knolls rising about 400 feet above low water, and covered with sand mixed with heavy ferruginous clay. The Carmichaels terrace is missing at the mouth of the creek; but it certainly did exist there, for at Clarksville on this stream, three miles from the river, rolled fragments mark the line at 250 or 260 feet above the stream. On the South fork of Ten-Mile this terrace is very distinct. At Jefferson there is a plain precisely similar to that at Carmichaels and on the same level. At Waynesburg is seen the peculiar blackened conglomerate already mentioned as occurring on Whitely and Dunkard. At Clinton, on the same stream, the conglomerate was found, but the terrace could not be traced from Waynesburg to that locality. The thickness of the detrital deposit varies from five to twenty-five feet.

"On the North fork of Ten-Mile, the terraces cannot be traced so as to determine their relations to those on the river; but the evidence of successive halts is sufficiently clear as far up as three miles above the village of Ten-Mile in Washington county.

"The soil on these terraces is altogether local in its origin, and in no way resembles the material distributed by the river."

1. *Upper Barren Measures.*

The structural features affecting this county have already been treated of in the general chapter on the structure of the district, and in the chapter on *stratigraphical geology* will be found generalized sections of the Greene county and Washington county groups of rocks which, with a limited section of the top members of the Upper Productive coal measures along the river, comprise the various rock exposures in this county.

The Greene county map will show by its coloring how large an area of the county is superficially covered by members of these measures.

In the detailed study given these measures in 1876, it was demonstrated with great clearness and skill, that the typical section of the Greene Co. group compiled from exposures in Centre township was of little comparative use in the northern part of the same county, and differed materially from that obtained along Fish creek in the extreme south-west; while in Washington a total different and *apparently* contradictory section caused a compilation of a new section to be used in illustrating that part of the field.

In all cases the criticism refers to the Upper Barren measures. For instance, the Fish creek section contains only four beds of limestone above the great Washington limestone with an aggregate thickness of 14 feet, as against nine limestone beds in Centre township, with a total of 52½ feet in thickness.

The two typical groups given in chapter IV are but portions of one grand group composing the *Upper Barren measures*; the Greene Co. group the *upper*; the Washington Co. group the *lower*.

The former has an extreme development of 800 feet, and is only satisfactorily exposed in Greene Co; the latter, while being 450 feet thick in the south as against 150′ in the north part of the field, is of much more importance in Washington Co. The line of division between the two groups is arbitrarily set at the *Upper Washington limestone* (No. VI) as being probably one of the most persistent and readily recognized members of the entire series. The group, as a whole, shows a decided diminution in thickness going northward from the Virginia line, and the combined effect of erosion and *the north-east rise in all the measures* have removed every vestige of this entire group of rocks from the highest hills in Allegheny Co.

The characteristic features of the *Greene Co. group* or upper portion of the *Upper Barren measures* are:—

1. The absence of workable coal beds everywhere.
2. The presence of only two coals that can be called persistent, viz: the *Dunkard* and *Nineveh coal beds.*
3. The vast accumulation of sandstone, especially in south-west Greene Co.
4. The presence of several beds of limestone, which increase in number and thickness going north from the West Virginia line, and to which the county owes whatever fertility and reputation as a grazing and farming district it already possesses.

The *Washington Co. group*, in Greene Co., occurring between the Upper Washington limestone and the Waynesburg sandstone at the base, is characterized by containing much more coal than the upper group, though the beds, five in number, are not so well developed with the possible exception of the thin Waynesburg coal bed. [See section plate].

The limestones are likewise thinner and fewer in number than in Washington Co. These facts will come out more clearly by reference to comparative sections in chapter IV.

In the group of five coals there are, in ascending order, two Waynesburg beds "A" and "B"; two Washington beds, the lower one distinguished by the prefix *Little*; and the *Jollytown coal bed*, quite persistent but rarely over 20 inches thick and of only local importance.

2. *Monongahela river series.*

This important series, with the Pittsburgh bed at its base and Waynesburg sandstone on top, has a fairly limited outspread in Greene Co. along Ten-Mile creek and the river township, and a small area on Wheeling creek in Rich Hill township.

The system is only fully exposed along the Monongahela river south from Greensboro', where its lowest member, the *Pittsburgh coal*, is brought up by the Fayette anticlinal to the south-east, and is elevated sufficiently along the West Virginia line, south of the Cheat river, to expose quite a section of the underlying Barren measures. The same thing is true at the mouth of Ten-Mile.

A section of the Upper Coal series, varying from 458′ to 487′ in thickness is given in Chapter IV page 65 which shows sufficiently well the character of its component parts.

The Waynesburg sandstone and the *Waynesburg coal* have both their greatest development in Greene Co., the former deteriorating west and north into shaly sandstone, and the latter forming the chief source of fuel supply to the people of Greene Co., outside the immediate vicinity of the river. Lying so much higher in the measures than the Pittsburgh coal, (400′±) it naturally spreads over a large amount of territory where that bed is under water level. In thickness however, it is very variable.

The *Uniontown coal* occurring about 90′ lower in the section, is a very persistent horizon here, in Washington Co., and many parts of Allegheny, though always worthless for fuel. It is frequently a bituminous shale.

Occurring immediately underneath this little coal bed is the upper division of the Great Limestone, which is likewise largely confined to this county in its typical form. The lower division 50 to 90 feet thick is much more widespread, and is not the land-mark in Greene that it is in the other counties lining the Monongahela river, there so often the top hill rock.

The *Sewickley coal* is next beneath the shale member of the Great Limestone, and attains its chief importance and development in Greene and Fayette counties—thinning northwards and becoming shaly. This bed is largely mined on Dunkard and Whitely creeks, where it is about 5½′ to 4′ 7″ thick, and lies about 110′ above the Pittsburgh coal.

The *Fishpot limestone* is a very variable stratum, occurring between two sandstones in the interval of 50′ ± between the Sewickley and Redstone coals. In the Waynesburg basin, along the Monongahela river, it is 30′ thick; but diminishes north and south irregularly, and in places, is altogether absent.

The *Redstone coal* in Greene Co. lies about 60′ above the Pittsburgh. Though persistent, it is very variable in size and quality. Here it contains, along the Monongahela, a larger amount of shale than coal, the former at Greensboro' being 13′ thick and the coal only 18″. It varies rapidly. The *Pittsburgh sandstone* separates this worthless coal, from the magnificent *Pittsburgh bed*, which is splendidly developed along the river in Greene Co., though as yet only available for country use, with rare exceptions.

It is exposed in Dunkard, Monongahela, and Jefferson townships of Greene Co., where the roof is often a massive sandstone, the roof-coal being very thin and the lower division developed as a splendid 9 foot bed.

3. *Pittsburgh series.* (*Barren measures.*)

These are the lowest rocks exposed in Greene Co., and here, as elsewhere, consist largely of sandstones and shales, with variable and obscure beds of limestone and coal.

The extreme thickness of this group exposed in Greene Co. is along the Monongahela river, near the West Virginia line, where the Fayette axis has brought up about 375′. Going down the river, these measures dip rapidly northward, and soon become buried in the Lisbon synclinal. The total thickness of the group here, as determined by well-borings, is about 425′, thickening northward.

The arrangement of the different townships in Greene Co. is somewhat as follows:

2. Morris, 3. Washington, 4. Morgan,
1. Rich Hill,
5. Centre, 6. Franklin, 7. Jefferson,
8. Cumberland,
9. Aleppo, 11. Jackson, 14. Whitely, 16. Greene, 17. Monongahela.
13. Wayne,
10. Spring Hill, 12. Gilmore, 15. Perry, 18. Dunkard.

Of these eighteen townships, only six can be considered pertinent to a discussion of the Pittsburgh coal region, viz: Morgan, Jefferson, Cumberland, Greene, Monongahela, and Dunkard. Indeed, so far as availability of the Pittsburgh coal bed is concerned, only certain portions of those bordering the river or the large streams need be considered.

In the remaining twelve townships, with the exception of a limited area immediately along Wheeling creek in Rich Hill township, the Upper Barren measures are the surface rocks, and the Upper Productive measures are buried from sight. It has already been shown how destitute of workable coal beds these upper measures are, despite the great thickness of the rock column comprising them. A detailed description of their resources will be found clearly stated in Part III of Report K., and the requirements of the region for comparative study of its mineral wealth fully set forth there. The six townships above enumerated may be designated as the *river townships*, though really no portion of either Morgan or Greene touches the Monongahela.

Broadly speaking it may be said, that all central and southern Greene Co. is without available coal, *i. e.*, *merchantable coal.* The *Dunkard bed* in the south-west, and the little *Nineveh coal* in northern Greene, are somewhat developed; but merely because nothing else in the way of coal can be reached without great expense in shafting, not warranted by the purely local demand. Neither of these beds attain any size or importance.

The *Washington coal* attains workable thickness only in Franklin township, near Waynesburg; but even here, it is of secondary importance beside the thicker *Waynesburg bed.* It is usually made up of alternate layers of coal and clay, difficult to separate, expensive to mine, and generally productive of disappointing results.

The *Waynesburg coal* is the chief source of supply for all portions of the district west of the river outcrops of the Upper Productive coal measures.

It is available along all the main streams entering the river on the east, as shown approximately by the coloring of the map, occurring just beneath the Waynesburg sandstone, whose *top* outline is shown by the junction of the two darkest tints.

The following are four analyses of this bed, made at the Laboratory of the Survey in 1876. (See Report K., p. 378):

	I.	II.	III.	IV.
Water,	2.265	1.175	1.180	1.235
Volatile combustible matter,	33.685	35.615	32.344	36.185
Fixed carbon,	49.590	49.725	51.582	46.723
Sulphur,	1.270	2.280	1.306	2.972
Ash,	13.190	11.205	13.588	12.885
	100.	100.	100.	100.
Percentage of coke,	66.315	63.210	66.476	62.580
Color of ash,		Pink.	Cream.	R. Gray.

I. G. C. Sayres, below Waynesburg, Franklin township, Greene county. (A. S. M'C.)

II. L. L. Minor, near Jefferson, Jefferson township, Greene county. (A. S. M'C.)

III. A. Groom, near Carmichaels, Cumberland township, Greene county. (S. A. Ford.)

IV. U. Lippincott, on Ruff's creek, Morgan township, Greene county. (A. S. M'C.)

V. Mr. Rogers, near Beallsville, Pike Run township, Washington county. (D. M'C.)

The percentages of sulphur and ash are both sufficient to condemn this coal for iron purposes, while the same objection would hold for its use in the manufacture of gas. However, in spite of its inferiority and the inferred difficulties of mining, owing to slate partings, this bed will always retain its importance to the people of Greene Co., owing to the inaccessibility of better beds.

As the other available beds of the Upper Productive series, are only obtained along what have been termed the "river townships," they will be referred to in the following brief description of the geology of these townships. These are the *Sewickley, Redstone* and *Pittsburgh coal beds.*

Township Geology.

Morgan township is the most northern of these, and lies west of Jefferson from which it is separated by Ten-Mile creek. The north fork of the same creek forms a portion of the northern border, along the Washington Co. line.

The erosion of this stream has exposed the Waynesburg coal, near the top of the Upper Productive measures, all along both forks. The highest rocks in the township are the Fish creek sandstone and limestone No. X (see section plate); the lowest is the *Sewickley coal*, which of course puts the Pittsburgh coal more than 100′ under water level. In the extreme northern corner of the township, along the north fork, these two coals—the *Waynesburg* and *Sewickley*—are about 250′± apart, and in the interval between them there is nearly 100′ of limestone, in six different beds. This will at once show the character of the measures, though usually the limestone is not so much split up as here. Near the Bollenfield school house, on this fork, the *Waynesburg coal* shows the following section:

Coal,	1′ 6″	5′ 11″
Clay,	1′ 5″	
Coal,	3′	

On the main creek the same coal crops on the State road, half a mile from Clarksville.

At the mouth of Casteel run, the *Waynesburg coal* is 190′ above the run; 1½ miles up the run it is opened at W. Stewart's bank, at the mouth of Bacon street run. The whole bed measures about 9′ in thickness; but in it there are three clay bands 1′ 1″, 2½″ and 1′ 3″ thick, which somewhat impair the integrity of the bed. The two lower benches however will yield over 5′ of coal while the lowest alone yields from 2′ 9″ to 3′ 7″.

A little further up Casteel run, the bed is 12′ 4″ thick at Mr. Cox's; but it is again a triple bed and fully half made up of shale and bands. The dip from Stewarts to this point is strongly north-west, the difference in elevation between the two coal openings being 30′ and the distance half a mile. The coal goes under the creek below Mr. T. Greenlee's house. On Hews run, the next above Casteel, the *Waynesburg coal* is 120′ above the level of Ten-Mile creek.

Up the road it has been opened by Mr. Hews and Mr. S. C. Orr, below the Centre school house. At both places the bed is triple; about 8′ thick; and very variable in quality and size. Some of it is good, free-burning coal, though high in ash; but the bulk of the bed is pyritous and slaty. It disappears about 150 yards below the school house.

Opposite Jefferson, on the property of Mr. D. W. Rogers, the *Waynesburg coal* has been largely grubbed; so too further up stream on Bells run, where the bed shows three benches 1′ 3″, 2′ 0″ and 3′ 2″, with two clay partings, 3″ and 1′ 3″ thick. Total thickness at the distillery bank 7′ 11″. It goes under water level beyond Mr. Bells house, losing a foot in thickness, and carrying considerable bituminous shale, commonly called cannel-coal in the vicinity.

Again is this bed opened on Jesse Bells property, east of Harry's school house, and below the State road. Here it takes up its typical form westward, showing two benches 1′ 7″ and 2′ 8″ thick, separated by 1′ 7″ of clay parting. The top bench seems to have graded into a bituminous shale.

On Ruff's creek there are several openings in the same bed, belonging to Mr. C. Harry. The bed carries here a heavy bituminous shale roof and is double, with a thick clay parting. The coal benches are 1′ 10″ to 1′ 7″ and 2′ 10″ to 2′ 8″ thick.

Below Martinsburg, on the creek, it is also mined before passing beneath water level. The section resembles Harry's. The ash and sulphur are both high.

The higher beds of the Upper Barren measures are met with at many places on all the creeks above mentioned and in the high dividing ridge along the Washington Co. line. They are of little importance however. Thus, half a mile from Clarksville, at Mrs. Cox's house, the *Waynesburg* "*a*" coal is seen at 65′ higher than the Waynesburg, with the sandstone intervening and marking the top of the Upper Productive measures; the *Waynesburg* "*b*" coal 115′ above; and the *Washington* coal 160 feet. The same measures are found on Bacon St. run, Hews and Casteel; while on the dividing ridge between Casteel and Ruff's creeks, the *Jollytown coal;* the *Upper Washington limestone* No. VI and finally limestone No. X on top the ridge. No special importance however can be attached to any of these, outside their geological significance.

Jefferson township is a long, drawn out area, extending from the Monongahela river above Millsboro' south-west nearly to Waynesburg. Ten Mile creek forms its north and west boundary; Franklin and Greene its south line with Whitely township cornering against its south-west limit; Cumberland township and the river its south-east and east lines. The *Pittsburgh coal* crops along the river at the extreme north-east corner, extending a short distance up Ten-Mile creek and soon passing beneath water level on the river into the Lisbon synclinal. Equally with Morgan township, the *Waynesburg coal* is exposed along Ten-Mile creek to and beyond the Franklin township line, as well as along the river bluff. Elsewhere it is deeply buried beneath a heavy covering of Upper Barren measures. Thus it is opened near Clarksville, and again near Burson's school house, a mile further up, at Mr. Shape's bank, where it shows:

Waynesburg coal, Shape's bank,	*Coal,*	1′ 0″	6′ 4″
	Clay,	5″	
	Coal,	1′ 3″	
	Clay,	1′ 2″	
	Coal,	2′ 6″	

Here the usual accompaniment of clay partings commercially ruins the coal.

Near by, Mr. David Bowser mines this coal, where the partings are somewhat thinner. And on Pumpkin run, at Price's bank, the same coal is opened.

At all exposures the coal is inferior. Jefferson is the principal point for the mining and consumption of this coal.

Rex's openings about a mile below the village have been quite extensively worked, and the following five comparative measurements of the bed are given in report K. p. 138:

Sections of Waynesburg Coal near Jefferson.

	1.	2.	3.	4.	5.
Shale, ...	1′ 0″	3′ 0″	1′ 0″	1′ 4″	0′ 10″
Coal, ...	0′ 9″	0′ 10″	0′ 8″	0′ 11″	1′ 3″
Clay, ...	0′ 3″	0′ 2″	0′ 3″	0′ 2″	0′ 6″
Coal, ...	1′ 11″	2′ 0″	1′ 4″	1′ 11″	1′ 7″
Clay, ...	0′ 8½′	0′ 6″	2′ 2″	1′ 5″	1′ 5″
Coal, ...	2′ 11″	2′ 6″	2′ 10″	2′ 11″	2′ 3″

The Waynesburg SS. overlies the coal, flaggy, and irregularly bedded in its upper portion. This coal has again been largely opened back of the College grounds at Jefferson, and at one opening the bed is reported to have swelled up to 10′ 9″ thick with four coal benches respectively 5″, 11″, 21″, 32″ thick. But the coal does not appear to be very good.

At Minor's opening at the upper end of the village the bed varies from 7′ 6″ to 8′ 4″ thick with three benches, 11″, 22″ and 35″ thick. Near Houlsworth's mill, the coal is 6′ 10″ thick in three benches 10″, 24″ and 28″ thick separated by clay bands 2″ and 18″ thick.

The Waynesburg has likewise been opened on Coal Lick, both in this township and Franklin. On Bush run, entering the river about a mile above Rice's landing, the *Waynesburg coal* was found 6′ thick at 285′ above the river or 1050′ ± A. T. Here also the *Uniontown* and *Sewickley beds* show each about 2′ thick, the former resting upon the Great Limestone, which occurs in two divisions, 8 and 85 feet thick, separated by 35 feet of shale and sandstone.

A mile further down, the *Pittsburgh coal* shows in the river, the section above extending to the top of the Upper Productive measures—the Waynesburg sandstone. This section is so complete and instructive as to warrant reproduction from Rep. K, p. 136:

1.	Waynesburg sandstone, seen	20′	
2.	Shale, ...	3′	
3.	*Waynesburg coal*, ...	5′	3½″
4.	Shale, ...	40′	
5.	Limestone, ...	6′	
6.	Sandstone and shale, ...	45′	
7.	*Uniontown coal*, ...	1′	6″
8.	Limestone, ...	6′	

9.	Shale and sandstone,	38′	
10.	Limestone,	82	
11.	*Sewickley coal,*	1′	9″
12.	Sandstone,	40′	
13.	Limestone,	25′	
14.	Sandy shale,	30′	
15.	*Redstone coal,*	1′	6″
16.	Flaggy sandstone,	15′	
17.	Massive sandstone,	30′	
18.	Top of *Pittsburgh coal,* in the river.		

The Waynesburg coal is here 360′ above the Pittsburgh. At a short distance below this the *Pittsburgh* coal is opened on Mr. L. Vernon's property as follows:

Sandstone,	30′	
Shale with coal,	1′	0″
Roof *coal,*	1′	2″
Clay parting,	0′	10″
Lower division *coal,*	7′	0″

The roof coal is rather impure and not taken out in mining. The bearing-in slate bands are present in the lower division coal, separated by 3″ of coal. The bottom and brick coal are in one bench 2′ 6″ thick, beneath the bearing-in.

At an opening on Ten-Mile creek, ¾ miles below Clarksville, the roof coal is 1′ 6″ thick and the lower division 6′ 7″ and main clay parting 1′ thick. The rest of the township is made up entirely of the Upper Barren measure rocks, to which in the absence of coal beds, but little interest attaches.

Cumberland township lies along the west bank of the Monongahela river from Rice's Landing to the mouth of Little Whitely creek, east from Jefferson and north of Greene and Monongahela townships. Muddy creek passes about midway through the township north-eastward from its south-west corner to the river, and drains a large portion of its area.

The *Pittsburgh bed* is everywhere under cover throughout the township, the centre line of the Lisbon basin entering Greene Co. at the mouth of Muddy run, where it is marked by a subordinate axis. The Upper Productive measures, *above* the Pittsburgh coal extend along the river bluffs and some distance up Pumpkin, Muddy and Little

Whitely creeks; while all the rest (two-thirds) of the township is occupied by the Upper Barren measure rocks.

The section extends from the *Sewickley coal* up to *Limestone No. V.* At the mouth of Little Whitely the Waynesburg sandstone caps the hill top, with the *Sewickley coal* in the river bed. At the first road-fork up the creek, the *Uniontown coal*, 3' thick and underlaid by a ferruginous limestone, outcrops with the *Waynesburg* 95 feet higher.

The latter bed also shows on the next road crossing the stream and half way to the Presbyterian church at G. W. Connor's where the bed measured (K p. 126):

Coal,	1' 1''	1' 1'
Clay,	0' 1'	0' 1''
Coal,	1' 6''	1' 10'
Clay,	1' 8''	0' 10''
Coal,	2' 8''	2' 9''

It was once quite extensively mined here for local sale.

At Ceylon P. O. the *Waynesburg* has been mined at several places, and at D. C. Stevenson's bank shows in good shape as follows:

Coal,	0' 10''	
Clay,	0' 1''	
Coal,	2' 0''	2' 2''
Clay,	0' 1''	0' 10''
Coal,	3' 0''	

The bed shows a maximum of coal here and is well spoken of. A salt well here determined the interval to the Pittsburgh coal to be only 324 feet. The outcrop extends well up to the east line of Monongahela township.

Below Little Whitely, on the river, the *Waynesburg bed* is opened on lands of Messrs. Parker and Houston, at 195' above river or 960' A. T. and shows with two clay partings over 7 feet thick. Between the Houston school house and the river the following section of the two rock groups, in part, is reported in K. p. 128.

1 *Washington Coal,*	blossom.
2. Concealed,	50' 0''
3. *Waynesburg "b" Coal,*	1' 6''
4. Imperfectly exposed,	40' 0''
5. *Waynesburg "a" Coal,*	1' 6''
6. Sandstone, Waynesburg,	70' 0''
7. Shale,	10' 0''

8.	*Waynesburg Coal,*	5′ 10″
9.	Fireclay and shale,	15′ 0″
10.	*Coal,*	1′ 0″
11.	Shale,	20′ 0″
12.	Limestone,	8′ 0″
13.	Shale and sandstone,	45′ 0″
14.	*Uniontown Coal,*	2′ 0″
15.	To river,	80′ 0″

The *Waynesburg coal* has been largely opened in a series of consecutive pits along the road, where the partings are very hard, and the coal generally full of ash and sulphur. In another mile down river the same bed is mined at 940′ A. T. or 175′ above the river at McClary's, showing about 7 feet thick with two slate partings 2″ and 1′ thick, dividing benches of coal respectively 1′ 2″; 2′ and 2′ 6″ thick.

At the mouth of Muddy creek, near the subordinate axis the *Waynesburg* is mined at Flennikin's Mine at 1000′± A. T. or 240′ above the river, the coal dipping south-east or up river towards the east sub-basin below Little Whitely. It is also mined at John Fuller's, a mile further down, showing 6 to 6½ feet at each place, with the *Uniontown* and *Sewickley* below it, and with the Great Limestone carrying only 8′ of limestone, sandwiched in between two heavy bands of sandstone and shale 40′ ± thick.

On Muddy creek, a mile or so from the river, the *Waynesburg coal* was opened on A. Burwell's land, where the coal benches are 11, 25 and 30 inches thick, and the outcrop is riddled with pits. The coal is inferior, and yields a bulky ash.

On Glade run, the same bed is mined, 1 mile east from Carmichael's on Messrs. Guseman and Grover lands where the coal shows in excellent shape, and above the average quality. It is open burning, rather free from pyrites and easily mined. Other openings show on a branch stream, above the last, on the lands of Messrs. Barnhart, Stevenson, Waychoff, and Bailey, are more or less described in the report of 1876 but very poorly shown now. The bed varies between 6 and 7 feet and always shows 3 benches, divided by a thick and a thin clay parting. The coal through this immediate region is much improved; but at its best, it is an uncertain bed, and generally slaty.

Of the coal on Muddy creek, ascending towards Carmichaels, the report of 1876 speaks as follows:

Just below Carmichael's at Horner's dam, there is an interesting exposure which exhibits a very complex division of the bed, and also the thin coal below, observed on Mr. Hewston's property. The section is—

1. Sandstone,		15′ 0″
2. Shale,		5′ 6″
3. *Waynesburg Coal,*		
1. *Coal,*	1′ 0″	9′ 1′
2. Clay,	0′ 2′	
3. *Coal,*	1′ 9″	
4. Clay,	2″ to 0′ 10″	
5. *Coal,*	2′ 2″	
6. Clay,	3′ 0″	
7. *Coal,*	0′ 3″	
8. Clay,	0′ 4	
9. *Coal,*	0′ 5′	
4. Shale with iron ore,		15′ 0″
5. *Cannel Coal,*		0′ 6″

This bed *commercially* is practically worthless.

Above Horner's dam the coal is exposed along the creek for more than half a mile or almost to Curl's mill, and an excellent exhibition of its variations is afforded. The upper benches are excessively impure. The lowest bench seems to contain rather less of pyrites, but is very far from being a clean coal. The upper parting is constant in its thickness and averages two inches. But the main parting varies abruptly.

The *Waynesburg coal* goes under water level at Carmichaels. Below Muddy creek, two miles down river, this bed is seen at Mr. Noble's in three benches, 6, 22 and 33 inches thick and 250′ above the river or 1010′ A. T. At Davidson's ferry the coal shows only two benches, 1′ 2″ and 3′ 6″ thick separated by 1′ 0″ of clay. The Great Limestone and the horizons of the lower beds of the Upper Productive measures are seen here.

At Baird and McClure's opening above Rice's Landing, the *Waynesburg coal* shows a similar structure, and the Great Limestone 7 and 80 feet thick, separated by 35 feet of sandstone. Other openings show on Pumpkin run; no better nor no worse than those already sufficiently described.

Monongahela township lies south of Cumberland, and faces the river from Little Whitely to Dunkard creek. Big Whitely creek takes a sinuous course through its centre, entering from Greene twp., passing through Mapletown to the river. The strength of the Fayette axis to the southeast has been sufficient to bring up about 200 feet of the Barren measures along the river, so that there is quite an extensive outcrop of the *Pittsburgh coal bed* from just above the mouth of Whitely creek, south to Dunkard. The effect of the anticlinal, with the erosion of Whitely creek has likewise served to confine the outspread of the Upper Barren measures to the north-western corner of the township, where the highest stratum exposed is the *Washington coal bed.*

The township is one of the most important commercially in the county. The openings in the *Pittsburgh coal* are not extensive however. This bed rises from the river in the neighborhood of Gray's Ferry, and a half mile south shows 10′ thick at about 30′ above the river, or 790′ A. T., in sixth pool. The coal rises steadily passing up river, and half a mile above dam No. 7 it is 830 A. T. At an old pit on public road below M. E. church it is 870′ A. T. Stevenson has opened the coal in the next ravine south at 890′ A. T.; and Gabler on adjoining land south at 895′ A. T. Finally the bed is opened on the Morgantown road at *Black's bank* 915′ A. T., and a section here answers for all the imperfect openings along the river. In about 300 yards from the pit mouth it gives:

Roof coal,			1′
Main clay slate,			1′
Lower division.			
Coal,	6′	0″	
Slate,	0	¼″	
Coal,	1′	0″	
Slate,		⅛″	
Coal,	2′	0″	

The partings in the lower division are almost imperceptible, and the whole 9 feet can be readily mined.

South and west from Greensboro', along the river road, the Barren measures are well exposed, especially the Birmingham shales, and Morgantown sandstone. When the river turns westward the measures sink for a little distance, and the Pittsburgh bed is about 150′ above the river. Various abandoned pits mark the bluffs at some little distance from the river, and even on Dunkard creek, in this township, the coal keeps pretty high above stream until approaching the Dunkard line.

The several other beds of the series are opened in various places, and both the Sewickley and Waynesburg are of workable thickness.

On the river road from Greensboro' to Mapletown, the *Sewickley coal* is mined and opened at several places. It varies from 5′ to 5′ 6″ thick, and is considered to have less sulphur and to be more open burning than the Pittsburgh coal. The *Redstone coal* is everywhere a thin seam with a thick mass of bituminous shale above and below. It is about 30′ above the Pittsburgh coal, and only 45 feet beneath the Sewickley. In Dunkard township, only three miles, the same intervals are 50 and 60 feet.

At Gray's Landing, back of the distillery, the *Sewickley coal* shows at 830′ A. T., or about 70 feet above the river.

It shows *coal* 2′; cannel shale 1′; *coal* 2′; total 5′ 0″. This bed is excellently exposed on Whitely creek in a number of places up as far as Mapletown, at about 870′ A. T. Near Minor's distillery, and the road above, the coal is rather poor. During the summer of 1885, these openings were largely idle and fallen in, and the following measurements at Hartley's mill are taken from K., page 12.

Sewickley Coal.

Coal, ...	0′ 9″	0′ 7″
Clay, ...	0′ ⅛″	0′ ¼″
Coal, ...	0′ 2″	0′ 7½″
Clay, ...	0′ ½″	0′ ⅓″
Coal, ...	1′ 11″	1′ 10″
Clay, ...	0′ 1″	0′ ½″
Coal, ...	0′ 7½″	0′ 1″
Bituminous clay, ...	0′ 2½″	0′ 2″
Coal, ...	1′ 1″	1′ 2″

"The bed has been broken up simply by the thickening of the partings. At Hartley's mill the top and bottom benches are evidently very fair clean coal, but the middle benches contain much sulphur, and the exposed surfaces are coated with copperas. The whole is easily mined, and for fuel is preferred to the *Waynesburg*, owing to the much smaller proportion of ash. The roof is a laminated sandstone, full of obscure vegetable fragments, and is very insecure. This is a serious drawback and prevents many from availing themselves of this coal.

"At Mapletown the openings in this bed are very numerous, but most of them are worked only during the winter. The insecure roof falls readily and chokes up the entry, so that in the summer or autumn one has much difficulty in procuring exact measurements. At the opening belonging to Mr. Debolt, the following section was made:

Sewickley coal.

Coal,	2′ 3″
Clay,	0′ ½—1′
Coal,	0′ 4″
Clay,	0′ 2″
Coal,	2 6′

The bed is similarly split up along the river, in places.

The *Waynesburg coal* shows 7′ 4″ thick below the mouth of Whitely creek on Mr. Geo. Evans' land, but split up into 5 benches of coal by 4 clay partings.

At *Minor Gray's opening*, ½ mile northwest, the bed shows benches of 1′ 3″, 2′, and 2′; dirty and sulphurous. The bed is about 240′ above the *Sewickley* further down the river, and shows about 6′ thick.

The *Waynesburg* is mined on the valley fork of Little Whitely by several persons, beginning about a mile from the main stream. Measurements made at three of these openings give as follows:

1. Shale,	10′ 0″		
2. *Coal,*	1′ 0″	1′ 0″	0′ 8″
3. Clay,	0′ 1″	0′ ½″	0′ ½″
4. *Coal,*	2′ 2″	2′ 1″	1′ 11″
5. Clay,	0′ 10″	0′ 8″	1′ 0″
6. *Coal,*	2′ 9″	2′ 11″	3′ 2″
7. Clay,	concealed	concealed	6′ 0″
8. *Coal,*	concealed	concealed	0′ 5″

The quality is reported as good here; but openings have been recklessly made. Near the corner of Cumberland twp. the *Washington coal* is exposed in the ridge between Greene township and the Monongahela river.

Greene township lies immediately west of Monongahela and between Cumberland and Dunkard.

It is off the river front therefore, and is without any outlet by water or railroad.

Whitely creek courses through it from west to east towards the southern portion of the township, and to its erosion and the general south-east rise of the measures towards the Fayette anticlinal in Fayette Co., is due the presence of the considerable area of the Upper Productive measures shown on the map, within its limits. But only a limited portion of this group occurs here.

The *Sewickley coal bed* passes beneath water level on Whitely creek near the eastern boundary, and at Vance's mill; a little over half a mile from the Monongahela line; this bed is 60 feet beneath the stream.

The *Uniontown coal* crops on the Morgantown road, further up stream, and is also occasionally seen above the Willow Tree P. O. on the creek.

The *Waynesburg coal* is mined south of the creek, along the Morgantown road by Messrs. South and Keener, and a little over a mile above the Willow Tree tavern, this bed also comes down near water level, and shows:

Waynesburg coal.	
Clay shale,	1′ 3″
Coal,	0′ 6″
Clay,	0′ 2″
Coal,	2′ 2″
Clay,	0′ 2″
Coal,	1′ 11″+

Finally *Saml. Minor's* opening shows this bed opened under 40 feet of Waynesburg sandstone cover with three benches of coal 0′ 4″, 2′ 3″ and 3′ thick separated by 1½″ and ¼″ of clay. The bed, therefore, is in first rate condition here, and this is said to be its character in the neighborhood. The partings are small and not hurtful.

The *Waynesburg bed* continues to fall going westward, up stream, and at Garard's Fort is scarcely 40 feet above the stream, finally disappearing beneath water level in the next half mile.

The Waynesburg sandstone then forms the creek banks until it, too, sinks beneath the surface and gives place to the *Washington coal bed* of the Upper Barren measures, which is constantly in sight near the road, from the residence of Mr. Lantz to the western township line. The same bed is thought to be near the surface on the road up Frosty run to Waynesburg, near Murdock's store. The northern half of the township is occupied entirely by the Upper Barren measure rocks, nowhere developed, considerably eroded into *debris*, and commercially unimportant. The Waynesburg synclinal probably passes through the north-east corner of the township, upon the presumption of its continued prolongation along Muddy creek ; but its true position is concealed.

Dunkard township occupies the south-east corner of the county, facing the Monongahela river, and lying north of the West Virginia line. It is a large and important township, well watered by Dunkard creek, which flows sinuously through its centre approximately. Lying much nearer the Fayette axis than any of the other "river townships" in Greene county, it shows a much larger surface area of Barren Measure rocks along the river and the creek, and a correspondingly decreased percentage of the Upper Barren measures.

The exposed rock section extends from 370 feet below the *Pittsburgh coal* to above the horizon of the *Washington coal.*

Crooked run approximately marks the West Virginia line, flowing alternately in each State, entering the river in Virginia, considerably above the Cheat river. Here the *Pittsbrugh bed* is at its highest elevation above the river, and nearest the Fayette axis, and the following section is reported in K. p. 90 :

1.	Sandstone,	30′	376′ 4″
2.	*Pittsburgh coal,*	7′	
3.	Concealed,	130′	
4.	Limestone,	5′	
5.	Shale,	15′	
6.	*Coal,*	blossom.	
7.	Sandstone,	95′	
8.	*Coal,*	2′ 4″	
9.	Shale,	4′	
10.	Clay shale,	8′	
11.	Concealed to river,	80′	

No. 7 is the first sandstone of the oil-wells in Dunkard creek, and, as here exposed, is irregularly massive to shaly. It is persistent in the river hills, being traceable quite to Morgantown in West Virginia, though it shows marked variations in structure. At many localities it is extensively quarried for building purposes.

The *Pittsburgh coal* occurs in two little detached patches here. Opposite the mouth of Cheat river it is 1140′ A. T. and is mined by Mr. A. Dillner, showing the following structure:

Sandstone,		30′
Shale,		8
Pittsburgh coal,		5′ 7″
Roof *coal,*	4″	
Main clay,	1″	
Lower division *coal,*	5′ 2″	

This shows a local degradation of the bed here which is usually about 10′ thick in this part of the field. At Mr. Field's opening, 1½ miles down the river, at Crow's Ferry, the *Pittsburgh bed* yields 9′ 7″ as follows:

Pittsburgh coal,	*Coal,*	6″	9′ 7″
	Clay,	3″	
	Coal,	8″	
	Clay,	1′ 2″	
	Coal,	7′ 0″	

The opening is north-west of Dillners and at about 1070′ A. T.

At the mouth of Dunkard creek the *Pittsburgh coal* is opened at 990 A. T., about 3 miles north-north-west of Dillner's opening, but not on line of greatest dip. The fall between the two places is 155′ or about 52′ per mile.

Along Dunkard creek the openings are pretty well abandoned for some distance and the coal lies high in the hill side. It crosses the State road in the creek bluff, and from there to its disappearance above Fairview or Taylortown it hugs the stream very closely.

At Bobtown, near the crossing of the State road the coal bed is opened on the Monongahela twp. side of the creek at 870′ A. T. It is capped with sandstone the roof division showing 3′± thick and the lower division (separated by only a streak of clay slate) showing *nearly* 6′ thick. The breast coal carries a 1 inch parting also.

Smith's pit lies further south-west, near the creek, on a small branch entering from the south-east at about 875′ A. T. The next openings occur just below Fairview or Taylortown, where the Pittsburgh sandstone is 25′ thick and massive. At *Taylor's bank*, the Pittsburgh coal is opened at 860′ A. T. *Hickman and Sullivan's pit* is a little nearer Fairview at 855′ A. T. and shows an irregular roof and the following section:

Sandstone, massive.		
Roof coal,	0′	4″
Clay slate,	0′	1″
Breast coal,	5′	7″
Bearing-in coal,		3″
Bottom coal,		9″+

Coal is left in the floor, and wagons are driven directly into the bank for loading. The dip is strongly north-west and the character of the coal mined none too good, though extensively used locally at Fairview.

Several other exposures of the bed occur in the next 250 yards at Fairview, where, near creek level the *South Pit* is opened at Maple's mill at 855′ A. T. Here the same section shows as above, with only 7″ of bottom coal exposed. Two hundred yards above this the coal passes beneath water level.

Near the Centre school house south of Fairview, the *Sewickley coal* is exposed at 975′ A. T., showing about 5′ thick, with two small partings and 3″ of bony coal on top. The same bed is opened about half a mile above Fairview on Dunkard creek, by Mr. S. Everly, 100′+ above the creek and about 5′ thick. It here shows only two divisions 2′ and 3′ thick separated by an inch of clay slate. It is at water level at the mouth of Meadow run, and mined there by John Debolt.

The *Waynesburg coal* is here 270′ above the *Sewickley*, and is mined further west near the township line by W. McClure, showing 4 benches, and in all 8′ 2″ thick. The coal is poor, variable and slaty.

On the State road just south of Wiley P. O. cross-road the

Sewickley coal shows 115′ above the Pittsburgh, but is not opened. East from here, a considerable area of this coal catches in the high hill south of the Greensboro' road, and has been opened in a good many places. The Great Limestone is likewise opened here.

Along the West Virginia line the *Redstone coal* crops near the Centre school house road at 20′ above Crooked run, at 1045′. In the valley of the run, east from this point, the *Pittsburgh coal* ("11 foot seam") is opened on the south side of the stream, 15′ above creek level, at 980′ A. T. This is *Garlow's pit*, and shows a slate roof, about 2′ thick, and about 6′ of lower coal, all under a light cover, and impure coal.

Up the creek from here the *Sewickley coal* is opened about 4 miles from the river at *John's pit*, showing two benches, 2′ 4″ and 3′ thick, and 260′ beneath the *Waynesburg coal* on J. E. Taylor's property near by. This latter bed flanks the stream to the western twp. line, opened at Bowlsby's, Watson's and on Smith run, showing everywhere a variable, impure coal, cut up with clay partings 7′ to 8′ thick, passing into Perry twp. Down Crooked run, from Garlows, the *Pittsburgh coal* rises steadily in the hillsides to the river. *Maples pit* is not far below Garlow's, and on the same side of the run at 985′ A. T. (in W. Virginia.) Going north up the State road, one mile from Rosedale P. O. the *Sewickley coal* shows at 1120′, above limestone.

The *Pittsburgh bed* is opened to the east of the State road at Van Voorhis, Brown, Miller and Titus around to the Greensboro'–Wiley P. O. road. The bed varies from 7′ at Millers to 8′ 4″ at Zion church, and to 10′ 2″ at Titus' bank facing Dunkard creek.

North of Dunkard creek, in the north-western portion of the township, the Upper Barren measures are everywhere the surface rocks, the *Waynesburg coal*, of the Productive Measures extending to half a mile above Davistown, where it is considerably mined.

The *Washington coal* shows along the Garard's Fort road; near McClure's school house on Lucas fork; near Bell's on Bowen's fork; at Wildman's on Glade run and near the Perry twp. line where it is about 10′ thick.

CHAPTER VIII.

Westmoreland County.

Westmoreland Co. is accorded an area of 1040 square miles in the Census Report of 1880. Its boundaries are somewhat irregular. and have been largely determined by the natural features indenting its four sides. Thus on the east, Laurel Hill forms naturally a dividing ridge, separating Westmoreland from Somerset and Cambria counties on the north, the Kiskiminetas or Conemaugh river separates it from Armstrong and Indiana counties, creating a natural route for the West Penn railroad and the old Conemaugh canal.

The Allegheny river forms its western boundary line for a short distance, but soon flows into Allegheny Co., which south from Parnassus, is irregularly separated from Westmoreland Co. by Pucketa and Turtle creeks, with intervening straight geographical boundaries; the Youghiogheny river between Crawford run and Sewickley; thence a straight line (the north boundary of Rostraver township) to the Monongahela river a little above Monongahela City, and thence *via* that river for a short frontage to the Fayette line at Bellevernon.

Fayette Co. lies to the south of Westmoreland. the dividing county line, between the two great rivers of the district, being straight between Bellevernon and Jacobs creek, and thence eastward following Jacobs creek to Laurelville, and then by a county road to Laurel hill.

Rostraver township occupying the extreme south-west corner, belongs *geographically* most naturally to Allegheny Co.

Geologically the county is divided naturally into several distinct parts, such as the

1. *Ligonier basin* on the east, between the two great ridges, Chestnut hill and Laurel hill.

2. The *Blairsville* or *Connellsville* (coking coal) *basin*

stretches north-east and south-west along the entire length of the county from Jacobs creek to Blairsville, lying west from Chestnut Hill and east from Huckleberry ridge, or the *Blairsville anticlinal.*

3. The *Greensburg basin* is another distinct trough lying next west of the Connellsville basin, and bounded on the west by Brush or Grapeville ridge, marking the position of the *Waynesburg* (Saltsburg) axis. It is continuous as a distinct basin from a little south-west of Greensburg, across the Loyalhanna a little below New Alexandria, to the tunnel at the big bend on the Conemaugh or Kiskiminetas.

4. The *Lisbon basin* lies still west of the Grapeville ridge and axis, a well defined trough, comprising the gas-coal territory, and extending from the Youghiogheny river at Port Royal, west of Manor station on the P. R. R.; west of New Salem, and reaching the Conemaugh about 3 miles below Saltsburg.

5. The *Murraysville* (Roaring Run) *axis* lies west of this basin, along Turtle creek; through Murraysville; Pucketa creek west of Oakland, and reaches the Conemaugh river at Roaring run. Other structural features are given in detail in Chap. IV, and need not be repeated here.

Manifestly the only portion of the county tributary to, and a commercial part of the *Pittsburgh Coal region* lies wholly within the Lisbon (Irwin) basin, and of that basin, only such parts as lie along the two rivers can be consistently treated of in this report.

Considerable time was spent along Big Sewickley creek, and the line of the South-West Penn. R. R., where the combined efforts of the Blairsville and Waynesburg (Saltsburg) anticlinals have exposed quite an area of the Lower Productive (Allegheny River) Coal measures.

The valuable maps of the Westmoreland Coal Co. have been used to make public, for the first time, the correct outline of the Lisbon trough north of Big Sewickley creek, and the numerous elevations of the Pittsburgh coal bed there, supplemented by personal examinations of the river districts, have furnished still further and reliable data upon the structure of this interesting coal field.

The plate opposite shows the general outcrop of the Pittsburgh coal bed in this basin between the Youghiogheny river and Salem, and the approximate position of the synclinal as determined by levels of the Westmoreland Coal Co.

The *topographical features* of the county are strongly marked and generally speaking, the hills mark the anticlinals and the unproductive coal territory; the valleys and low country, the productive coal basins. Both the high ridges on the east rise to over 2500′ above tide; their sides are steep and rugged, and their crests are made up of rocks occurring beneath all the true coal-bearing formations.

Brush ridge, already mentioned, is really split in two in this county, the eastern split, known as the *Huckleberry ridge*, keeping rudely parallel to Chestnut ridge and flanking the Connellsville basin on the west; the western split, called *Brush* or *Grapeville ridge*, swinging westward around the west side of Greensburg trough.

The forking becomes most distinct north of Big Sewickley creek; and both ridges are occupied by anticlinals. Along this double ridge, the Barren measures are generally the surface rocks, though in portions of their extent, the Lower Productive measures are brought up on the crests of the anticlinal axis. All the north-western portion of the county, along and west of the Murraysville axis, is high country, occupied quite generally by the Barren Measure group, and showing every diversity of character in its deeply eroded topography. The various coal basins of the county, while occupying a generally less elevated position, are nevertheless by no means gentle and regular depressions.

The *Ligonier basin* especially, composed largely of Barren measures and the rugged sandstones of the Lower Productive group, is largely made up of rough, sharp hills, and a rough topographical outline.

The *Connellsville* and *Greensburg* basins, being entirely composed of the Upper Productive rocks, show these features to a less extent, while in the *Lisbon basin*, especially along the south and west portion, where the Upper Barren measures are still retained, the hills are much more smoothly rounded and evenly eroded.

Indeed, to one familiar with the distinctive characteristics of the various rock groups occurring in this part of the State, the topography of any special district is a useful indication of its surface geology.

Along the immediate lines of the Monongahela and Youghiogheny rivers, the bluffs are quite steep and rugged; but back from those rivers, the country rises gradually in successive terraces or benches, to the higher hills marking the anticlinals. The valleys made by the streams cutting across the county, the Kiskiminetas, Loyalhanna, Sewickley and Jacobs creeks, are usually narrow, especially in the gaps through the ridges.

The *drainage system* is comparatively simple, as the map will show, for nearly all the principal streams rise in Laurel Hill or Chestnut Hill and flow eastward to the Monongahela and Allegheny rivers.

The *Conemaugh river* is the only stream cutting through both these ridges. Its course is mostly north-west to the Allegheny at Freeport, though with many intervening detours. Though receiving a large amount of water from the counties lying north of it, its drainage area in this county is quite large.

With its chief tributaries Hendricks and Tub Mill creeks at Bolivar; the Loyalhanna further west at Saltsburg; and Beaver run in Washington twp. at Apollo, it practically drains all of northern Westmoreland. *Loyalhanna creek* is by far its most important branch. Rising in Laurel Hill, it flows north-westward across the Ligonier valley; cuts through Chestnut ridge by a grand gap; across the Connellsville basin to Latrobe and thence to New Alexandria and through the Greensburg basin to the river. This stream always carries a large volume of water and is of paramount importance to the region it traverses.

Beaver and *Pine runs* are lesser tributaries further west, but drain considerable areas.

Pucketa creek is the next most important stream entering the Allegheny river at Parnassas and forming the county line for some distance. It partially drains Burrell and Washington townships.

Turtle creek is next south, also in part a county line, and tributary to the Monongahela, which it enters on the south-west and west course at Port Perry. With its tributary, *Brush creek* (along which the P. R. R. extends) it largely drains Franklin, Penn and North Huntingdon townships.

Big and Little Sewickley creeks unite about 1½ miles from the Youghiogheny river at Sewickley, and together drain a very large portion of south-western Westmoreland county, south of the Penn'a. R. R. and west of Chestnut ridge, comprising parts of Sewickley, North Huntingdon, Hempfield, South Huntingdon, Unity, Mt. Pleasant and East Huntingdon townships. Big Sewickley has opened a conspicuous valley in Brush ridge, along the S. W. Penna. R. R.; but westward the hills contract again, and the valley narrows to an abrupt gap which continues almost to the river. Little Sewickley creek rises near Grapeville, and soon cuts across the Lisbon basin in Sewickley twp. to the river.

Jacobs creek is the last important stream, forming the Fayette Co. line, and draining the northern townships west of Chestnut ridge as it does the southern part of Westmoreland, in North and South Huntingdon and Mt. Pleasant. It is an uncertain source of water supply, though a stream of considerable size and importance.

Transportation facilities in this county, are mainly provided through the railroad lines.

The Penna. Central R. R. extends half across the county from Stewart's Sta. and Turtle creek to Beatty sta., where it turns north-east to Latrobe and across the Connellsville basin to Bradenville. Here it turns sharply north-east and follows parallel to Chestnut ridge through the beautiful valley of McGee's run to Blairsville Intersection. From this point it follows the Conemaugh into Cambria Co. Branch lines connect the main road with the industrial portion of the county, mainly to the south.

The *S. W. Penna. R. R.* is the chief of these, extending from Greensburg south to Overton *via* Big Sewickley creek, and thence through the coking field, throwing out branch lines to all parts of the district.

The *Sewickley R. R.* is a private line, operated by the Penn Gas Coal Co., extending from Irwin's, through the gas-coal region to a junction with the B. & O. R. R. at Sewickley, on the Youghiogheny river.

The *Manor branch* is a recently constructed feeder, extending north from the P. R. R. at Manor Sta. intended to develop the Irwin basin to the north of the main line. It is built 39 miles to Claridge by way of Harrison City.

The Baltimore and Ohio R. R. and the Pittsburgh and Lake Erie R. R., both have branches touching this county along opposite sides of the Youghiogheny river, and it is by means of these two roads and the Monongahela river navigation that the coal considered tributary to the *Pittsburgh district*, is shipped to market westward.

The *Ligonier Valley* R. R. serves to connect Ligonier and Latrobe, and partially gives the people of the Ligonier Valley access to the outer world. The amount of coal carried by it is proportionately small.

Structural Geology.

The structural features of the county are generally quite plainly marked.

The most striking irregularities occur in the *Blairsville-Indiana* axis and the *Saltsburg-Waynesburg* axis which seem to almost come together in the vicinity of Sewickley Mills, diverging northward on opposite sides of the Greensburg trough.

To the south-west, the Waynesburg axis lies clearly much further west, and from where it was faintly noticed, just beyond the county line, on the Youghiogheny river, it seems to grow stronger proceeding south-west to Bellevernon, contrary to the general law of subsidence in that direction. The location of the anticlinals and synclinals will be given in the township geology to follow.

Stratified geology.—In this county, treated as a whole, a much lower series of rocks are exposed than in any of the counties thus far described; especially in the eastern half, where the great anticlinals of Chestnut ridge and Laurel hill have elevated the sub-carboniferous rocks to daylight, on their crests.

But it has already been stated that only that portion of the county lying west of the Saltsburg anticlinal—and this only to a limited extent—comes within the province of this report, so that the rocks of this district are all comprised in a section extending from the *top* of the Lower Productive measures to the *bottom* of the Upper Barren measures.

Owing to the gradual elevation of *all* the measures along a north-west course, and a general shallowing up of the synclinal basins in that direction too, a large portion of the rock-groups covering Greene and Washington Co. are conspicuously absent here, and in their stead, the underlying Upper Productive and Barren measures spread over the surface almost everywhere. Thus the *Greene Co. group* (the upper division of the Upper Barren measures) is *wholly* wanting in this county, and of the lower sub-division of that series—the *Washington Co. group*—only limited areas are still occupied by them, and these are confined solely to the Lisbon basin south of Big Sewickley creek. And the whole series here is very obscure.

Thus in Report KK. p. 26 *et seq.*, Prof. Stevenson hesitatingly identifies the *Washington* (upper) *limestone* No. VI—the top rock of the bottom group—on Shepler's Knob, in Rostraver township.

The *Jollytown coal* is not identified. The great *Middle Washington limestone No. IV* of the south-west seems to have entirely disappeared in this latitude, and the same may be said of *Limestone No. III.* The *Lower Washington No. II limestone* however, immediately overlying the *Washington coal*, is present in Rostraver and South Huntingdon townships where it is an excellent limestone 6′ to 8′ thick. The *Washington coal bed* outcrops in Rostraver and South Huntingdon townships, and very probably in Sewickley and North Huntingdon. An opening in South Huntingdon shows an extreme development of 9 feet, made up of alternate layers of slate and slaty coal. The sudden variation in size and quality in this bed makes it a practically worthless commercial coal.

Of the remaining strata of this group, the *Little Washington coal* and Limestone "I b" are wanting; Limestone "I a", overlying the *Waynesburg "a" coal* is persistent as a 5 foot ferruginous rock. So too is the coal, though always thin and unimportant, and lying immediately above the Waynesburg SS.

The map coloring will show the very limited area occupied by this group of rocks. No economical importance can be attached to any of its numbers.

Upper Productive measures.—The rocks of this series have been found in every trough of the district, and have an uninterrupted spread in the Lisbon basin from the Monongahela river north-east to Washington township, where they have been cut out by Beaver run, and afterwards occupy but a small area of the basin between that run and the Kiskiminteas river.

The generalized section of these measures given in chapter IV of this report, as well as the singularly clear and terse description of their character and variations in the different basins given in report KK., removes the necessity for detailed attention to them here.

Prof. Stevenson has demonstrated by numerous sections in his report that there is a perceptible diminution in the intervals between the beds going northwards in each trough, as well as westward from the Lisbon trough. This is an important fact to remember, though it will appear more apparent when comparisons are made between Fayette and Westmoreland counties, than in the more limited field of any one county. The extreme thickness of the group east of the Monongahela river, is in round numbers, 440 feet.

The *Waynesburg SS.*, at the top of the group, is present in the Lisbon trough of Westmoreland Co. as far north as the N. Huntingdon line; but throughout it is quite shaly and partakes but little of the massive character it assumes further south. It is 70′± thick.

The *Waynesburg coal bed* is quite persistent, though generally thin. In Rostraver and S. Huntingdon it rarely exceeds 3 feet, but is of excellent quality. In N. Hunting don it is thinner, and generally worthless. It has been identified in this basin as far north as Indiana Co.

The *Little Waynesburg coal* is separated from the upper bed by about 20 feet of thin, flaggy sandstone. In Westmoreland Co. it is merely a black shale.

The *Waynesburg limestone*, beneath the last little coal, is persistent throughout the Lisbon basin, 10′ thick in Rostraver; 7 feet in S. Huntingdon; 5 feet thick in Hempfield and N. Huntingdon, and 7½ feet in Penn township, which seems to limit its extent northwards. Between it and the *Uniontown coal below*, the rocks are mainly sandstones and shaly sandstones.

The *Uniontown coal bed*, resting immediately on top of the upper division of the Great Limestone, is present in the Lisbon trough as far north as the Pennsylvania R. R., but always thin and of no commercial value.

The *Great Limestone* here shows considerable variations in detail from its characteristics as displayed in Greene and Washington counties. In the southern portion of the Lisbon trough, in this county, it forms a marked and readily recognized stratum in the measures as far north as the N. Huntingdon line. But followed northwards to the railroad, it becomes shaly and disappears, considerably decreasing the interval between the Uniontown coal and the lower division of the Great Limestone. The lower division of this *Great Limestone* attains its greatest development in this trough, and extends as far north as the lowest member of the group—the *Pittsburgh coal* bed. However it loses its distinguishing characteristics northwards, and beyond the Penna. R. R. its variations in size and quality are sudden and extensive.

On the Fayette line, it is about 55 feet thick, and at Markle's mill, on the Sewickley, it is more than 70 feet. In the Youghiogheny shaft of the Penn Gas Coal Co. it is only 15 feet thick, and along the Penna. R. R. it is 12 feet in a cut near Shafton, 7½ feet in the Westmoreland Coal Co's. shaft near Manor station, and 28 feet in a railroad cut near by. In a boring north of the railroad it is 20 feet thick, and hereabouts it is about 100 ± feet above the *Pittsburgh coal* bed.

The *Sewickley coal bed*, beneath the above described limestone, is readily traced in the Lisbon trough as far north as the Sewickley creek, but beyond that its position is uncertain. It is here always a rich bituminous shale, rather than a coal bed, from three inches to two feet thick, though obtaining considerable importance as a coal bed further south, in Fayette county.

The *Fishpot limestone* occurs below the Sewickley coal, with which its relations vary considerably in the Lisbon basin. Its occurrence north of the Youghiogheny river is uncertain and excessively irregular, being present on the east side of the basin as far as Sewickley creek, but it disappears on the west side before reaching Rostraver township. In S. Huntingdon township it is fully 20 feet thick, and a limestone of great purity.

The *Redstone coal bed* extends as shale or coal well beyond the Penna. R. R. It is 4′ thick on the Youghiogheny and Sewickley, but thins to 3′ before reaching the Little Sewickley creek. On the Penna. R. R. it shows 1 to 3 feet thick, at about 80 feet above the *Pittsburgh coal*, and was identified as far north as the Freeport road in Washington township.

It is mined to a limited extent, for local use, in Rostraver, S. Huntingdon and Sewickley townships; and while neither very sulphurous or dirty, it is seriously troubled by clay-veins and horse-backs, rendering it a treacherous mining bed. Beneath this coal a thin limestone is frequently found, though of uncertain and irregular occurrence in the basin in Westmoreland county. It has, however, been identified at various points between the Youghiogheny and New Salem. It has a ferruginous character. The interval between the Redstone and Pittsburgh coal beds varies considerably throughout this district, but through the Lisbon basin, in Westmoreland county, the gap is largely made up of shaly and flaggy sandstones, some carbonaceous shale, and in places an intermediate thin coal.

The *Pittsburgh coal bed* is here, as elsewhere through the region, a superb seam of coal, always persistent, with but slight variations of thickness, and of workable dimensions at all exposures.

Throughout the county it may be said that the *Pittsburgh bed* is always accessible, for though lying beneath water level in the Connellsville (Blairsville) and Lisbon basins, to a greater extent than in some of the troughs further west, it is always within reach of shallow shafts, and is subject to less variations of dip than in areas where it is more readily attacked. Moreover, to Westmoreland county belongs the distinction of furnishing the typical coking and gas coals of the United States, and, with Fayette county, it annually distributes to far distant points about 75 per cent. of all the coke made in the country.

Throughout the Lisbon basin in Westmoreland county the bed yields a high grade of gas coal. It furnishes a good shipping lump-coal highly prized for steam purposes, while the nut and slack are largely utilized in the coke ovens. The bed here shows a distinct parting into benches, so typical of its occurrence further west. But in the basins lying to the east, and running south into Fayette, these benches are not so plainly marked to the casual observer, and the bed shows a tendency to consolidate into one large bench from 7 to 10 feet thick, with a couple of thin slate partings. The roof here is generally good and firm and adds considerably to the safety and economy of mining.

There are local troubles, swamps, clay veins, soot veins, horsebacks, etc. here, as elsewhere: but as far as developments have gone, such disturbances are more serious in the neighborhood of the Penna. R. R. than elsewhere. At this place, both the Westmoreland and Penn companies have had serious difficulties to contend with (See Report KK. pp. 338 et. seq. and chapter X of this report), and the damaging effects of sandstone, horsebacks, and soot veins, have destroyed a large amount of coal for commercial purposes.

The Pittsburgh coal in the Lisbon trough is continuous from the Monongahela to above New Salem, and the outcrop and levels of the coal between these points, are accurately located upon the map accompanying this report.

Within the country, between these points the bed shows a north-east rise of about 32 feet per mile, being about 600 feet A. T. on the Youghiogheny, 750 feet at the Penna. R. R. and 1300′± feet to the north-west of Salem, the distance between Port Royal and the north-east crop beyond Salem being about 22 miles. These figures are, of course, only approximate; but they conclusively demonstrate the gradual lifting of the basin in a north-east direction.

The *Barren Measures.* This series of rocks is quite largely represented in Westmoreland Co. and in the immediate portion of the district under discussion.

The whole system is fully exposed on the crest of the Saltsburg axis, as well as along the other anticlinal arches crossing the country; along the Kiskiminetas and largely throughout north-western Westmoreland, west of the Murraysville axis, where they are almost the sole surface rocks, carrying only a few patches of the lowest Upper Productive rocks north of Pucketa creek in Burrell township. They are the highest measures crossing the Murraysville —Roaring Run axis in this county, except in the immediate vicinity of the Kiskiminetas and Beaver run, and the characteristic topography created from their diversified erosion has beautified all that portion of the country for the tourist, while, at the same time, robbing it of all its economical wealth.

The yielding nature of the various slates and shaly sandstones, comprising this series, adds also to the geologist's difficulties in constructing reliable sections; while on the other hand, the farmer, with a little care and attention, finds this same rapid disintegration highly advantageous to the production of a remunerative soil.

It seems hardly necessary to treat this system in detail; for outside the valueless results to be obtained from an economical point of view, the whole ground occupied by them has been skillfully gone over in Report KK. A generalized section of this group of rocks, some 300 feet thick, has already been given in Chapter IV on *Stratigraphical geology*, and the different areas in the county occupied by them is clearly shown by the coloring on the map accompanying this report. As coal-bearing measures, they are utterly unproductive, the five or six beds recognized as geological components of the section, being in every case, there, worthless and treacherous.

The two great sandrocks the *Connellsville* and *Morgantown* occurring in the upper half of the series, between the *Pittsburgh coal* and the *Crinoidal limestone*, attain importance in portions of the county, as building stones; but in the Lisbon basin and contiguous territory, neither is apt to be massive or of special quality, while quite persistent as either sandstone or shaly sandstone.

The *Crinoidal limestone* and the *Barton coal bed*, 25 to 40 feet above, are also quite persistent members of this group; but both have only geological significance as guides to the more important measures above or below them.

As a whole, the Barren Measure group seems subject to rapid and irregular variations in the thickness and character of its rocks. Thus on the Monongahela river the entire series between the *Pittsburgh* and *Freeport coal beds* is not much over 400 feet, while on the Youghiogheny river, on the Fayette axis, the same interval is over 500 feet, which is about the interval on the Conemaugh river. Moreover the excessive and sudden variation in the individual strata is very confusing, and completely breaks down all rules for the comparison of two sections made within short distance of each other.

The *Lower Productive Coal measures* are but sparingly represented west of the Chestnut ridge. Along the Conemaugh river and on some few points along the course of the Saltsburg and Blairsville axis, this series is brought to daylight. But as far as the immediate region under report is concerned the section extends but little below the *Upper Freeport coal*, or top member. This coal however is everywhere persistent where its horizon is met with and occurs in isolated areas, more generally perhaps than shown on the map, wherever erosion and the action of the anticlinals have been sufficient to uncover its outcrop. It is well exposed on Big Sewickley creek from 2 to 5 feet thick; on Little Sewickley south of Grapeville where it is double, showing *coal* 3′; clay 2′ 6″; coal 5′; total 10′ 6″. On the

Loyalhanna and Conemaugh it is from 3½′ to 5′ thick in a single bed, along the Saltsburg axis; and from 4′ to 8′ thick under the Murraysville anticlinal. It can hardly be considered a regular or important commercial coal bed. The *Mahoning SS.* capping it is always present too as a massive sandrock, readily recognized.

Township Geology.

In discussing the township geology of the limited portion of south-western Westmoreland Co. coming under the jurisdiction of this report, very little need be added to the introduction just finished beyond mention of some details respecting the features of the *Pittsburgh coal bed.*

While it has seemed best, in order to preserve the integrity of the Lisbon basin so far followed from the West Virginia line, to present the general description of this trough north of the Penna. R. R. in Westmoreland Co. which will immediately appear, no attempt was made during the field season, to enlarge upon the details of this basin, north of the Youghiogheny river, already graphically described in Report KK. From Mr. Humphreys' Chapter X on the mining methods pursued at the extensive mines of the Westmoreland and Penn Gas Coal Companies, in this basin, some additional geological features of interest are presented in new lights; while for the general student of the geology of this district, it has been thought wise to collect together, from all sources, salient facts to assist him, and the general reader, in collating results with those already presented from personal investigations made further south-west, in this same trough.

In the north-eastern end of the field, near the Salem cross roads, the position of the synclinal axis can only be approximately located owing to the limited developments there. However it is fairly midway between the eastern and western outcrop, the basin here being about 3 miles wide.

In the stream below the Burnt Cabins summit, the coal outcrops on the eastern side of the basin at about 1200′ A. T. The crop swings south-west from here to Salem, crossing the public road just west of the cross-roads at 1272′ A.

T., and keeping a pretty straight south-west course for about 3 miles to the headwaters of Brush run, where it crops on the north and south sides of the ravine at 1103′ and 1089′ A. T. respectively. The synclinal here passes about 6000 feet west of the road forks, and in a bore hole situated on a left hand branch of Brush run, the elevation of the *Pittsburgh coal* is 845′ A. T. From data obtained by this boring a fair estimate may be made of the rate of rise along the axis north-eastward. The distance to the crop on the Washington twp. line west of Salem is a little over 4 miles and the difference in elevation of the coal 330′± or a rate of *about 80′ per mile.* The north-west dip, into the basin is also severe, amounting to (1090–845) 245 feet in 6000 feet.

On the western side of the basin the dip is much more gentle. The distance from the bore hole to the western outcrop is about 12,000 feet and the difference in elevation (1165–845) 320′±.

To the south-west, the synclinal probably passes near or a little west of Harrison City, keeping still well on the east side of the basin. The eastern outcrop is somewhat broken but lies about 9000 feet due east of Harrison City, keeping a little west of south to the Pennsylvania railroad at Penn sta., where it is considerably cut out by Brush run. It flanks the railroad track west from Penn sta., crossing to the south side just beyond the bridge over the creek, and is carried under water level on the stream just north of the railroad at 947′ A. T. This part of the basin is developed for about 1½ miles north-east of the railroad by the Penn Gas Coal Co.

Between outcrops along the immediate line of the railroad, the basin is considerably narrowed by reason of the erosion of Brush run, and cannot be more than 3 miles wide on an east and west line.

The western outcrop of the Pittsburgh coal extends east along the railroad to Irwin's cut-out by the creek; but the real western limit of the basin is beyon Larimer's sta., as shown on the map, a strip of barren measures extending along the track between Larimer and Irwin. The synclinal axis crosses the railroad between Manor and Westmoreland

City at the railroad bridge over the creek. The coal here is about 750′ above tide.

Between here then and the shaft already mentioned, the distance along the synclinal approximates 4½ miles and the difference in elevation (845–750) 95 feet or but 21′ per mile.

The western side of the basin, north of the Pennsylvania railroad, enters Penn township from the south (after leaving North Huntingdon and Brush creek), about a mile north-east of Larimer's station, extending north-east for about 2 miles, when it returns upon itself, in a narrow strip, and crosses the Newtown and Murraysville road within ¼ mile of the township line. At the head of this ravine, the coal disappears at about 950′ A. T. Here the crop again turns north for two miles, until again cut out by the south fork of Lyon's creek.

The crop extends eastward along this branch for nearly a mile before turning north once more, reaching the Harrison City and Murraysville road after a series of detours around the headwaters of the stream, at about 1150′ A. T.

The south-east dip here amounts to about 170′ per mile. The outcrop extends possibly 500 yards west of the cross-roads, before crossing the Murraysville road and returning upon itself, after passing around a hill, to within 100 yards of the cross-roads. Here in one of the several benches of the north fork of Lyon's run, it crops at 1148′ A. T.; at 1070′ A. T. at the head of the next branch, further east, and extends 800 yards up a north branch to 1105′ A. T.

Returning again on the west side of this branch the coal is opened at the point of the hill at 1112′ A. T. turning then north-east again in Franklin township to the Salem–Murraysville road. Here the outcrop is again quite seriously cut out along the creek, north-west of Manordale.

South of that village, in a bore hole at the head of one branch of the creek the *Pittsburgh coal* was struck at 152′ below the surface or at 1000 A. T. Other elevations around here are shown on the map.

Along the main stream (which heads up near Salem) the crop extends for nearly a mile, and disappears at about 985′ A. T., within 1200 yards of the synclinal, and only about 2000 yards from where it appears again on the east side of the trough, higher up on the same stream. Returning westward on the north side of this stream, this outcrop extends for over two miles up a north branch, turns back on itself for a mile, and then finally passes north-east to join the crop in Washington township at the head waters of Beaver run. A long, narrow strip of coal extends north-east in Salem township, between branches of Beaver run, as shown on the map, before being cut out entirely by the creek, from the area lying between it and the Conemaugh river.

No portion of this part of the field north of the Penna. R. R. was visited—lying wholly without the province of this report, and the details of structure, character of bed, and general geology must be sought for in report K. K., on Fayette and Westmoreland.

The special features affecting the district south of, and adjacent to the Penna. railroad, are likewise referred to in that report, while the peculiarities of the coal bed, and the prevailing methods of mining are further explained in Chapter X of this report. The remaining portion of the Lisbon basin, between the P. R. R. and the Youghiogheny was partially examined, to supplement the immediate river district, but not with the intention of reviewing this important field, which is distinct in itself. It will now be described by townships:

Township Geology.

North Huntingdon township lies immediately east of Allegheny county, south and west of Penn and Hempfield townships in Westmoreland, and north of Sewickley. The Pennsylvania railroad crosses it in a north-west and south-east direction, along Brush creek, and the Youghiogheny railroad connects Irwin sta. of that road, with the B. & O. R. R. at the mouth of Sewickley creek. The Youghiogheny railroad just touches the extreme south-west corner.

A small patch of the Upper Barren measures lies just south of the Greensburg pike in the eastern portion of the township; but the Upper Productive measures form the surface rocks, through by far the larger part.

The Barren Measures however, occupy a considerable area in the north-western part of the township, as the map will show, owing to the presence of the *Murraysville—Roaring Run anticlinal*, which crosses the Penna. R. R. midway between Stewart's and Carpenter's stations, and lifts these lower rocks to the surface.

The *Lisbon* (Irwin) *synclinal* passes through the eastern extremity of the township, crossing the P. R. R. just west of Manor station, so that the prevailing dip is toward the south-east. The exposed section reaches from the *Washington coal bed* to about 400 feet below the *Pittsburgh coal.*

The western outcrop of the *Pittsburgh coal* is considerably broken, and largely under very light cover. It is everywhere excessively irregular, and extends east along the Penna. R. R. to Irwin station, and from there north along Coal run, in a narrow strip nearly to the Penn twp. line. On the south side of the railroad and Brush creek, it extends west, with many detours, for about 3 miles into Allegheny Co., doubles twice upon itself along the county line on the headwaters of Long run, and crosses the Greensburg pike outside the township in Allegheny Co. It enters again near the Youghiogheny river, and after being deeply indented by Crawford's run, extends along the river front into Sewickley township.

The coal in this township is comprised in the heart of the famous gas-coal district. The large mines of the region are either owned or controlled by the Westmoreland and Penn Gas Coal Companies, whose product is known for its high grade of gas making fuel throughout the country. The former company mines from six different openings in the township, with a total output in 1885 of 484,337 tons, according to the report of the Secretary of Internal Affairs. The Penn Gas Coal Co. during the same period report shipments from four of their seven mines in this and Sewickley township to the extent of 609,899 tons.

The typical gas coal of the country is shipped from these mines, and out of scores of analyses the following may be taken to fairly represent the character of these coals :

	Westmoreland.	*Penn.*
Water,	1.427	1.280
Volatile matter,	37.521	38.105
Fixed carbon,	54.921	54.383
Sulphur,	.713	.792
Ash,	5.418	5.440

The location of the various openings are shown on the map, with the respective elevations of the coal above tide. Time did not permit me to go outside of the district to examine these openings; but whatever regret may have been experienced in the failure to do so, is compensated for in a measure, by the graphic and excellent account of this field given in Prof. Stevenson's report K. K., pp. 338 *et seq.*

Sections of the coal show the usual variations in different parts of the field, and the local changes near lines of *fault* or *swamps* are presented in Chapter X of this report.

At one of the Penn Co's. mines, along Coal run, the entire bed shows a thickness of 14′ 3″ (K. K., p. 339) of which amount 7′ 4″ is roof coal, and 6′ 3″ lower division.

At the Westmoreland Co's. mines at Irwin, the roof coal was measured at one place only 2′ 1″ thick, and the lower division of the bed measured 6′ 6″ as follows: Breast coal 3′ 9″; bearing-in 5″; brick 10″; lower bottom 1′ 6″. The breast coal is said to carry a persistent parting in the extensive mines of the company here, occurring at about 7 inches from the top, and somewhat pyritiferous.

As a rule the lower division is very regular, both as regards structure and thickness and is readily mined. Rolls and swamps occur in these mines and in this field generally; but in mining they are skillfully overcome and cause no serious embarrassment; and frequently horse-backs of sandstone cut out the roof-coal entirely and cap the mining portion of the bed. Clay veins are persistent and run in all directions, and in a measure they affect adversely the quality of the coal and therefore its commercial value.

Most of the country pits along the western outcrop of the basin are largely fallen in and abandoned, the coal right in the different properties being largely held by one or the other of the large producing companies. On Long run the coal is mined by Mr. Robinson 989′ A. T. near where it passes beneath water level and on the Youghiogheny river, several openings are still seen.

The coal crops on the west side of Crawford's run at 879′ A. T. dipping rapidly south-east, so that where once mined at the old *Robbins and Jenkins* mine, facing the river, it was opened at 797′ A. T. This was the old Scotch Hill mine; but work has been entirely suspended for several years.

The *Blythe Mine* (Youghiogheny and Ashtabula Coal Co.) lies about 500 yards up river at 782′ A. T. The main tunnel was driven in something over 600 yards in August '85 and drained naturally to the pit mouth, south-west along this face entry, except at a point about 530 yards in, where some little irregularity of dip had to be overcome. The butt entries driven south-east, on the dip, were then drained into a closed swamp about 6 feet below the tunnel and the rear crop in Possum hollow. From this swamp the water was syphoned. The north side butts drained naturally into the main tunnel. The lower division coal is something over 6 feet thick, and the limestone under the coal is well exposed along the river bluff 8 to 10 feet thick. The production of coal at this mine during 1885 was 57,000 tons.

West from Crawford's run, in Allegheny county, the coal outcrops around the narrow point at Coultersville, and is opened at two places along the crop to Osceola station, where the mine workings are really extended into Westmoreland Co.

The *Alpsville Mine* (Thos. Hackett and Co.) is the first of these, situated about a mile below Coultersville and at 892′ A. T. The coal here all dips rapidly back into Crawford's run and it would seem that this ravine would have properly been selected for the opening. The mine however was opened in 1864 when the slack-water system of the Youghiogheny was still in operation. All the coal now is shipped on the B. & O. R. R. and during 1885 the output was 81,390 tons—a large product.

The mine is opened on the single entry system, ventilation and drainage being secured through several openings in the crop in a little depression to the south-west of the pit mouth. The old workings were all extended to the north-east of the main double butt entry, and consequently drained themselves. The new workings lie south of the main entry and drain south-east to a water level gangway driven to daylight in the little ravine just mentioned. The coal still continuing to dip south-east, beyond this water level gangway, the rear workings are drained to openings near the head of the hollow. The slack coal was all being coked here.

The rise of the measures is very rapid towards the north-west so that the coal is opened in the point between the river and Long run at the *Osceola Mine* at 955′ A. T. about 200 feet above the track. A long incline extends to the pit mouth, and a wire rope haulage was used through the mine—opened partly on double, partly on singly entry system. The mine was idle in Aug. '85, but during that year produced 43,484 tons of coal. The bed section is about as usual, in this part of the district.

Other active and important operations in this township are located along the line of the Youghiogheny railroad—mostly conducted by the Penn Gas Coal Co.

The following record of the Youghiogheny shaft exposures was furnished by Mr. F. H. Oliphant, Jr., then in charge, and is reproduced from Report KK. on account of its integrity and the story it tells of the character of the Upper Productive measures in this part of the field. The top of the shaft is not far below the horizon of the *Uniontown coal*, and Nos. 2 to 7 are evidently the representatives of the Great Limestone, indicating its degeneration northwards :

1.	Washed material,	10′	6″
2.	Limestone,	2	6′
3.	Limestone and clay,	5′	0″
4.	Shale,	7	
5.	Shale rock,	7′	
6.	Compact slate and shale,	21′	
7.	Limestone,	15′	
8.	Soft shale,	18	
9.	Light blue sandstone,	26	
10.	*Coal bed*,	1′	to 3
11.	Black shale,	8′	
12.	Shale or nodular limestone,	14′	
13.	Sandstone,	2	

14.	Compact shale,		14'
15.	Light colored sandstone,		2
16.	Sandstone, with crushed fragments of coal,		2' 6"
17.	Sandstone,		7' 6"
18.	*Pittsburgh coal bed,*		11' 2"
	Roof division,	4'	
	Main clay,	0' 10"	
	Lower division,	6' 4"	

No. 10 is evidently the *Redstone coal bed*, and the *Sewickley* seems to be entirely absent. The *Pittsburgh coal* here is of the same general character as in the Westmoreland Co.'s mines and is subject to the same local imperfections and troubles, while maintaining its thickness and superior quality everywhere.

East of Irwins, along the Penna. R. R., at Shafton Sta., the *Shafton Coal Company* reached the coal by a shaft 150' deep and at 775' A. T., still dipping south-east, and a mile further south-east along the track, is the *Westmoreland shaft* (W. C. Company) 175' deep, striking the *Pittsburgh bed* at 750'± A. T.

The roof members of the bed are somewhat thicker here, showing coal benches of 25 and 31 inches, separated by 14 inches of clay. The lower division however is persistent as at Irwins, and shows about 6 feet of coal. The shaft is not far from the centre of the basin.

Sewickley township lies next south of North Huntingdon, and faces the Youghiogheny river from Guffey's station on the B. & O. R. R. to Sewickley station at the mouth of that creek. It has Sewickley creek for an irregular southern boundary, with Hempfield township on the east.

The developments are mainly confined to the river front and Sewickley creek, and the section of exposed rocks extends up to the *Washington coal* (?) in the Upper Barrens, and down to the top of the *Morgantown SS.* below the Pittsburgh bed.

The structural features of the township are somewhat confused. Owing to the convergence of the *Saltsburg* and *Blairsville anticlinals* (8 miles apart on the Pennsylvania railroad and enclosing the *Greensburg basin*) in the region of Sewickley Mills, in Hempfield township, the course of the *Lisbon* (Irwin) *synclinal* is deflected also to the south, after entering from N. Huntingdon township, about a mile west of the north-east township corner.

After passing a little west of Fulton P. O., it takes a course not far from a straight line between the Methodist and Presbyterian churches, south of Little Sewickley creek, and meets the Big Sewickley creek between Markles and Bell's mills, but a little nearer the latter, and thence to Port Royal on the Youghiogheny.

Throughout its course here, the *Pittsburgh coal* is deeply buried, and there are no sufficient guides to its accurate and specific location.

It was shown likewise, in the preliminary report of 1885, that the *Waynesburg anticlinal* touches the Monongahela river south of Webster, passed through Rostraver township in Westmoreland Co., sinking rapidly *north-eastward* and showing a faint roll on the Youghiogheny river below Pollock's run, in Allegheny Co. This axis can not be prolonged through Sewickley township, although a gentle reversal of dip shows there between Suter and Sewickley stations.

Elevations along Sewickley creek are somewhat troubled and hard to account for, except by the total subsidence of this Waynesburg axis a short distance north of the river, leaving a rolling, underground structure to be eventually associated with and more sharply defined by the rise of the *Saltsburg axis* to the north-east.

It is evident that the Waynesburg axis has no connection whatever with the Roaring Run—Murraysville axis, lying six or seven miles further west, on the west side of the Monongahela river.

The subsidence of the Waynesburg axis is made still more probable from the fact that the prolongation of its course north-eastward between the two rivers, would strike directly into the line of the synclinal axis of the *Lisbon trough.*

The structure of this whole south-western portion of Westmoreland is extremely interesting though as yet obscure, and careful records should be kept of the rise and fall of gangways in the various mines of this district, the direction of the same carefully plotted and the depth of bore-holes all referred to a general map, before anything positive can be asserted of the variations in structure which evidently exist here. The first openings in the *Pittsburgh coal* are found just south of Possum hollow and the N. Huntingdon line, along the river.

The *Shaner Mine* (Shaner Gas Coal Co., Limited), situated on the B. & O. R. R. near Shaner's station is the first opened at 790′ A. T.

Although a little further north the abandoned pit of the Youghiogheny Coal Hollow Co.—the *White Ball mine*—shows the bed a little above track level at the old coke ovens, as follows: Main clay parting 1′; Breast coal 3′ 4″; Bearing-in 4″ andBrick and bottom coal 1′ 6″; total 5′ 2″. Roof coal about 3′.

The Shaner mine drains north-west and south-west to the pit mouth and Coal hollow, and the coal seems to be rising quite distinctly to the south-east. Very few of these mines along the river were in operation when visited during the fall of 1885 and but little could be learned of their special features. No returns of production were made here.

Between this point and Buena Vista, Greenawalt hollow cuts out the coal a little back from the river, and at the head of each branch of the hollow, the coal is slightly higher than on the river front. East of the hollow, along the railroad the coal is opened at 808′ A. T. while to the west it shows in a little ravine, back from the road at 805′.

At Buena Vista, the river turns squarely south, and the *Armstrong mine* (Shaner Gas Coal Co.) is opened near the station of that name at 813′ A. T. These works has been entirely abandoned, and the coal run out from the Shaner mine opening of the same company. The drainage here is still westward.

South from here the measures are lying very flat and but little above the track so that in about a mile:—

Ocean Mine No. 1 (Youghiogheny River Coal Co.) at Scott Haven is opened at about the same elevation above tide, 812′. The opening is about 30′ above the B. & O. station here, correcting therefore the elevations given on that railroad in the report of 1885, and making Scott Haven 792′ instead of 763′ A. T.*

All the front coal at this opening was worked out by single entry system, although now the double entry plan is adopted in the new workings.

The old main tunnel is driven S. 65° 30′ E., and after being carried in some distance, turns squarely north-east on face N. 26° 00 E. to a continuation of the main tunnel, now driven double. Two butt entries Nos. 1 and 2, 3 and 4 intervene between the two positions of the main gangway, and all the entries east of the single face entry are driven double. From the point of the angle the face entry is continued S. 26° W., and made double, and a butt entry runs from it north-west to connect with a small drain entry leading out to the ravine south of Scott Haven. All the front coal is drained to this point. The butt entries running east, and north of the main tunnel all dip gently south-east to the rear property line.

The main tunnel itself drains slightly that way; Nos. 1 and 2 butts, the first entries south, are nearly level if not *rising* a little south-east, while Nos. 3 and 4 dip into the head of a *swamp*, lying close to the rear property line and running north-east and south-west. It crosses Nos. 5 and 6 a little further west, and is 8′ deep there. All the water is collected there and syphoned out of the pit mouth.

The lower division benches are respectively 44″, 4″, 12″, and 12″, the lower bottom being pyritiferous. The daily output is about 600 tons, and the production for 1885, 115,166 tons. The river now takes up a course nearly parallel to the axes, and the coal first falls to 787′ A. T. in the ravine at Jas. Guffey's, and then rises rapidly as it approaches Suter's sta. and the *Waynesburg anticlinal* to 843′ A. T., in the ravine back of the station. The river takes another bend to the south-east here, and the coal rises a couple of feet in the next half mile to the crown of the axis at the *Amieville mine* (J. N. Bigley) at 845′ A. T.

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* No further success was attained in the endeavor to obtain the correct elevations along this division of the B. & O. R. R., the officials of the company showing a singular indifference to the importance of the work, and the issues dependent upon it.

This mine is opened on single entry system, although the main tunnels are driven double.

The present main entry is driven on face 1200 yards long, and the coal on No. 2 Butt entry shows benches of 41″, 4″, 10½″, and 15″ from main clay to limestone.

There is a small swamp in this entry about 100 yards from the main tunnel, where the roof has been cut down for grade. From this point back, the water will drain in. Soot veins and small swamps are frequent here—a condition of things to be expected from the position of the axis. Air-courses are driven every 160 yards, and coal mined in blocks 150 by 180 yards.

This property comprises all the coal north-west to Sutersville along the river front, and three butt entries are driven out to the crop in the ravine already mentioned. In one of these entries the coal makes two rolls before getting to the outcrop, in one place being 12′ above the level of the main entry, and falling 12′ into a swamp just before reaching Sutersville hollow. The output in 1885, was 75,000 tons, all shipped by rail.

The *Republic mine* (Republic Coal Co.) is opened at 834′ A. T. There is a small knuckle between this mine and Amieville, 500 yards distant, so that the fall south-east is only 9′. From this point the fall is rapid, and soon carries the coal beneath water level beyond Sewickley creek. The Republic mine was not in operation when visited, and nothing is known of its operation, outside its production in 1885, of 23,783 tons.

The *Penn Gas Co. mine* is the last on the river to Sewickley creek, and is opened 37′ lower than the last at 797′ A. T. This is the No. 4 drift from which the company run 600–700 tons daily. In No. 4 entry a measurement of the coal showed:

	Main clay,	
Lower division.	Breast *coal*,	3′ 4″
	Bearing-in *coal*,	4½″
	Brick *coal*,	10″
	Lower bottom coal,	1′ 0″—1′ 3″

The breast coal varies but little through the mine, except in the swamps met with. The brick coal varies from 9 to 14 inches, and is separated from the bottom coal by a 2″—3″ sulphur band. The bottom is 12 to 15 inches thick, and is not mined. The mine is opened on double entry and greatly troubled with swamps. The main entry is quartered; dips 9″ per 100 feet for 900 feet, and then rises. It makes two turns to the left of 5° each to keep within the coal. The quality of the coal is good, and yields 33 per cent. of lump over a ¾″ screen. The roof coal in the main entry shows:

1.	*Coal*,	9 ″	3′ 8½″
2.	Slate,	6½″	
3.	*Coal*,	1′ 4 ″	
4.	Slate,	1 ″	
5.	*Coal*,	1′ 0 ″	
6.	Main clay,	10 ″	

Nos. 5 and 6 are taken down throughout the mine in the rooms for general safety and better roof.

Both here and in the shaft workings of this company up Sewickley creek, the rooms are opened by "double headers," with the advantage, it is claimed, of getting all headings in this way that would otherwise be lost in narrow workings. There is 40′ between entries, the latter being 7½ feet wide. The depth of room is 300 feet, and entry pillars 12′ by 30′. This system of working is illustrated in Mr. Humphrey's article, Chap. X.

The outcrop extends from here up Sewickley creek nearly to the junction of Little Sewickley. Several pits were formerly opened here, or are out-lets of the Penn workings, and show little variations of section. The elevations are 776′, 776′ and 764′ A. T. at creek level, and are therefore, lower than those north-west along the river front.

The *Penn Co.* reach the coal by a shaft 70′ deep above here near a serious swamp, reversing the coal dip for a distance of 300 yards and creating a fall of 50 feet.

The eastern outcrop of the *Pittsburgh coal* in this basin heads down Big Sewicleky creek for about 2 miles below Waltz mill before passing beneath water level. It is opened in several places between that point and the Hempfield line south of Madison, and shows an average section like:

Main clay parting,	1′ 2″	7′
Breast coal,	4′ 0″	
Bearing-in,	4″	
Brick,	1′ 2″	
Lower bottom,	1′ 6″	

At the *Fulton & Jinkerton Mine* it is considerably developed, and shows an excellent quality of coal, but little troubled with swamps or irregularities of any kind.

The *Redstone coal* shows 50′ ± above this 4′ thick, and the *Sewickley coal* and Great Limestone high in the hill.

The lower division of the latter is about 85′ thick and passes below water level on the creek below Bell's mill. The upper division goes down as far as Markle's mill, where it shows 15′ thick with the *Uniontown coal resting upon it.* The Upper Barren measure areas are shown on the map. They are poorly exposed and unimportant.

Hempfield township lies east from N. Huntingdon and Sewickley, and takes in a limited area of the Upper Productive measures along those county lines. For this reason, and owing to the presence of the Lower Productive measures, with the *Upper Freeport coal* along Big Sewickley and the head waters of Little Sewickley, it may be considered in connection with the general field examined; although by far the greater part of the township lies entirely outside the district.

For instance, fully one half of the area of the *Pittsburgh coal* exposed in the *Greensburg basin* is contained in this area, while of that portion of the bed contained within the *Lisbon basin* it is extremely doubtful if, when developed, its coal will find its way to market through the Pittsburgh region. The examinations along Big Sewickley creek were mainly made with a view to establish the position of the anticlinal flexures which have elevated the Lower Productive measures to daylight along the country contiguous to the S. W. Penna. R. R.

The *Greensburg trough* is here a closed basin, shelving up like the end of a canoe south-west before reaching the Sewickley creek in the neighborhood of Sewickley mills.

As already explained, the Saltsburg and Blairsville anticlinals, lying on either side of this basin, bring about this result by their convergence towards a common point on the Sewickley, although it is extremely donbtful whether the former axis can be traced and its position located much south of the latitude of Middletown.

This axis enters the township on the north about 1 mile east of the Penn township line, passes just into Penn and then back to Hempfield, crossing the Penna. R. R. at Grapeville station and the Greensburg pike near Grapeville village, bends towards the south and elevates the Freeport coal on Little Sewickley creek. This deflection in the axis has allowed the coals of the Lisbon basin to spread into the western part of this township.

The Penn Gas Coal Co. mine the Pittsburgh coal along the Penna. R. R. on the eastern side of this basin. Here the bed is said to be seriously troubled by clay veins and swamps, and the following is a fair example of the bed structure:

Roof division,		4' 0"
Coal,	1' 0"	
Clay,	0' 4"	
Coal,	2' 0"	
Clay,	0' 2"	
Coal,	0' 6"	
Main clay parting,		1' 0"
Lower division,		6' 0"

The lower division benches are 43, 2½, 12 and 14 inches thick. The outcrop then passes south and crosses the Greensburg pike about ¼ mile east of Adamsburg, and the Middletown road about 1½ miles distant from Adamsburg. On the Baughman and Errett place the lower division of the coal shows 6′ 3″ thick with benches 45, 3, 12 and 13 inches.

A mile further south towards Arona, the bed is opened on the Croushour and Eisman properties, without change. The crop extends for some distance up a small branch of Little Sewickley creek, north-west of Arona, returning on the west side, and passing beneath water level on the main stream about ½ mile S. W. of Arona. On the south side of the creek, the crop heads up a ravine, and then swings around towards the Madison and Greensburg road, where it is again opened, just north of the road at *Brisbin's bank* showing:

Roof division,	2' to 3'	
Main clay parting,	1' to	6"
Breast coal,	4'	2"
Bearing-in,		3"
Brick,	1'	6"
Lower bottom,	1'	4"

The lower bottom is sub-divided 4 inches from the bottom by a narrow slate band. The coal is extensively opened here.

The outcrop reaches to within ½ mile of Madison, where there are several openings showing at one place:

Roof division,			
Carbonaceous shale,		5''	11'
Coal,		6''	
Clay,		10''	
Coal,	2'	0''	
Main clay parting,	1'	3''	
Lower division coal,	7'±		

In the Lisbon basin, outcrops of the *Redstone coal*, the *Great Limestone* and the *Waynesburg coal* are occasionally met with in this township, and the Great Limestone and Waynesburg limestone are both burned for lime. The Barren Measures show likewise going east to the Saltsburg axis, notably the Crinoidal limestone west from Grapeville, and 40' above the Morgantown SS.

The *Lower Productive series* is partly exposed on Little Sewickley creek south-south-east of Grapeville, its top coal —the *Upper Freeport bed*— cropping for nearly 2½ miles along the stream, under the arch of the Salisburg axis. All the openings on this coal have been long since abandoned and to report KK. is due the information gathered here.

On Mr. Hanes' property, a mile below Grapeville the bed is reported:

Coal and black shale,	3'	
Clay,	2'	6''
Coal,	6'±	

Nothing very favorable can be said of the character of the coal.

On Big Sewickley creek, the exposures are nearly as unsatisfactory, only one opening having been found in operation. The stream meanders for several miles across the axis so that the coal bed is kept above water level for a considerable distance. To the east the outcrop extends nearly to the Mount Pleasant line, passing beneath Wilson's run, west of Weaver's old stand. As the coal was largely used in the several salt works which lined this valley in past times, its disuse naturally followed the abandonment of these works.

Opposite Foxtown station, on the S. W. Penn R. R. is the old *Painter's Salt works*, a deserted opening shows at 1020′ A. T. where the bed is said to have yielded only 2′ of coal. The crop crosses the public road south at about the same elevation and then extends south-east around a prominent ridge and up a stream entering at Paintersville, to two abandoned pits on either side of the run, at 1015′ and 1020′ A. T. The bed goes under water level just east from these pits, and in the next 400 yards along the road, the Mahoning SS. shows.

Further down the stream, south-west, the coal was once opened at *Fry's pit* at 1025′ A. T., extending up a ravine nearly to his house. Continuing down on the east side of the creek the coal is next opened near its disappearance on the road from Sewickley mills south-east into E. Huntingdon township, at *Wallace* and *Highberger's pits* at about 1040′ A. T. Both openings are concealed with grown-up bushes, and must have been abandoned for some time.

Immediately south over this ridge, and on Belson's run, *Highberger's pit* is opened about 40′ above the run at 1000′ A. T. and a quarter mile east of Hunker station on the S. W. Penn R. R.

The bed here is very variable and changes from 1′ 6″ to 4′ in a comparatively short distance. It is capped with a heavy (Mahoning) sandstone roof, with sometimes an inch or two of slate intervening.

When the coal has its full thickness a thin slate shows at about 1′ from the bottom. The bottom bench is always persistent, the rolls and irregularities coming in the upper coal, next the roof. Bearing-in is done on this thin slate and the bottom bench yields the best and softest coal.

The coal extends probably ¼ mile further up this run, and returning on the south side has been opened nearly opposite Highberger's, at *Belson's bank* 1010′ A. T. Though largely filled with water the pit showed about 3½′ of coal above the slate band, capped with 4 inches of bone and slate to a massive sandstone roof. Beneath the band about 10″ of coal showed to water. Passing south-west around this hill, the crop is exposed at Hunter's, just above the road at his house at 1020′ A. T. and now in E. Huntingdon twp.

From there it extends possibly ¾ miles up Buffalo run, along the railroad track, and about midway between Hunker and Bethany stations, the coal was formerly opened on the Armstrong place at track level, passing beneath water level in the next quarter mile.

On the other fork of Buffalo run, west, the coal was opened at *Brien's pit* at 1030′ A. T., the entry heading N. 50° W., and the coal draining in that direction. The sandstone lies directly on the coal here, squeezing the bed somewhat, which shows at pit mouth 2′ 2″ of top coal, 3″ of slate, and bottom coal 1′ 11″. The bed is somewhat irregular; has somewhat columnar cleavage; coal soft and purest in bottom bench.

Further up stream 250 yards, the bed disappears, but was opened at *Thompson's pit*, about 20′ above creek level, at 1020′ A. T. This bank is just above the old saw mill. The coal shows 4′ 8″ thick, and is of good quality. The top bench is 40″ thick beneath 1′ of shaly sandstone and then massive rock roof. The parting slate is 2″ thick.

J. Harrold's pit lies on the south side of the main creek, on a small branch heading south in S. Huntingdon twp., and some little distance north-west of the last mentioned openings. The pit is about 990′ A. T., and ¼ mile west of the railroad. The opening is in an unusually good condition, comparatively speaking, and was formerly largely mined from to supply the salt works near by. The dip is N. W., and bed section shows:

Roof sandstone.

Upper Freeport coal.	Bone coal,		2″	4′ 2″+
	Coal,	2′	6″	
	Slate,		2″	
	Coal,	1′	2″+	

The bed section varies, and is said to show 5′ 8″ when well under cover. On the north side of Sewickley creek here, two openings on this coal are seen about a mile below Hunker's old carding mill. These are on land of Messrs. Fulton and Beck, and show:

Upper Freeport coal.	*Coal,*	3′ 6″	2′ 10″
	Clay, ...	1″ to 3″	1″ to 3″
	Coal, ...	1′ 6″	1′ 5″
	Clay, ...	——	1″
	Coal, ...	4″	5″

The top coal is here bony, and the structure of the bed prismatic, with soot veins and pyrites common. The roof is Mahoning sandstone somewhat flaggy.

Near Col. Fulton's the Upper Freeport limestone is seen 1′ 6″ thick at about 12′ below the limestone.

Other openings in this coal bed might be noted, in following the outcrop along the western side of the creek from its disappearance about 1½ miles above Waltz mill, north to a mile above Foxtown. But no new features are presented by it, and the openings are abandoned and obscure.

The *Lower Freeport coal* is likewise above water level along the upper end of the creek, and on Wilson's run to Ruff's salt works, where it is 4′ 1″ thick, in two main coal benches 10″ and 1′ thick. Other openings show the bed 3′ 10″ on Painter's property.

South Huntingdon township lies south of Sewickley along the Youghiogheny river with Jacob's creek for its south line. The *Fayette axis* reaches the latter stream about 3 miles from the river, and crosses the township to the north-east corner at Sewickley creek, and may be considered a south-western prolongation of either the Saltsburg or Blairsville axes from that point, but more probably the latter.

The *Lisbon synclinal* cuts the West Newton pike a little over 2 miles east from the town, and passes south-west to the river at Port Royal.

The eastern outcrop of the *Pittsburgh bed* enters on Sewickley creek about a mile above Bell's mills, passes a little east of School House No. 4, and the West Newton pike at Mr. Robertson's house. From here it trends south-west for two miles, and approaches to within about a mile of the river at Smithton, on a small branch at Lees mill and school house No. 12.

Thence it curves around the south-west corner of the township, and when within a mile of Jacob's creek, bends west and north, and meets the Youghiogheny barely ¾ miles above Smithton station on the B. & O. R. R.

The first opening on the north, near Sewickley creek is *Gott's pit*, where it shows 10′ 7″ thick, the four benches of the lower division measuring 50, 4, 14, and 18 inches thick. On the West Newton pike it is opened at *A. Robertson's bank*, where the following complete section of the bed was measured by Prof. Stevenson (K. K., p. 355):

Roof division.			
Coal,	10″	3′ 8″	12′ 3″
Clay,	1′ 0″		
Carbonaceous shale,	4″		
Coal,	4″		
Clay,	2″		
Coal,	1′ 0″		
Main clay parting,		10′	
Lower division.			
Breast *coal,*	4′ 11″	7′ 9″	
Bearing-in,	4″		
Brick,	1′ 0″		
Lower bottom,	1′ 6″		

This is a fairly typical section of the bed in this region. South from the pike, openings occur at Messrs. Painter, Shupe, Rhodes, and others, and a number at Lees mill. Here the roof division is 2′ 7″ thick, with coal benches of 7, 4, and 8 inches thick separated by clay bands of 10 and 2 inches. The lower division is 7′ 4″, and the benches 58, 4, 12, and 14 inches, making in all 10′ 5″. The coal is good, and yields a high percentage of lump size. On the river hill, about a mile south of Smithton station, the coal is 11′ 1″ thick, and the benches in the lower division 60, 8. 4, and 17 inches thick.

Along the river, south of the Sewickley line, the openings are not numerous, owing to the depth at which the *Pittsburgh coal* lies; but the operations are extensive and important. The bed passes beneath water level on the north, about a mile south-east of the mouth of Sewickley creek, and just where the river bends sharply to the south.

The *Youghiogheny Slope* (Youghiogheny Gas and Coal Co.) is situated on the B. & O. track, a few hundred yards further south, where the coal in an air shaft is about 34′

beneath surface, and is reached by a slope at 790′ A. T. The mouth of the slope is about 20′ above the B. & O. track, and the coal is about 75′ vertically below the pit mouth. The working division of the bed shows benches of 41, 4, 14 and 12 inches thick. The mine was idle when visited. All water collecting in the pit is pumped out of the slope from below, and the bulk of the territory lies between the slope and Sewickley creek. The output in 1885 was 38,175 tons.

The *West Newton Co.* have two shafts down to this coal on either side of the river, the bed lying at about 707 A. T. and within the town limits. Though twice visited, neither maps, an entrance to the mine, nor information of any kind could be obtained from the company's representative. The output in 1885 was 61,081 tons.

From here the coal continues to sink along the river to the bottom of the Lisbon basin at Port Royal, where the *Port Royal Coal and Coke Co.* have likewise shafts sunk to the coal 205 and 180 feet deep, the coal elevation being 606′ A. T. on the east side and 610′ A. T. on the west, with connections beneath the bed of the river. The working portion of the bed is here about 7 feet thick, of which amount the breast contains 5′ ±. It is not quite so thick on the west side of the river. Mining is generally carried on above the bearing-in bands, leaving the brick and bottom coal in the mine.

Mine No. 1 on the east side develops generally up the river, with the rise of the coal, although the bed is usually quite level hereabouts. Both operations are worked on double entry system, and are well managed and planned. A single gangway connects both shafts, 140′ beneath the river. In mine No. 2 all the drainage is towards No. 1 shaft, and is pumped out of the shaft there. The mine entries are exceedingly regular, only one trouble having recently been encountered in No. 2, where a face entry on the north-west has taken a sudden dip at 19′, and may lead into a swamp. The average run from both pits is about 425 tons a day, the total output in 1885 having reached 28,904 tons.

The Great Limestone members crop along both sides of the river from here to beyond West Newton.

To the south, the measures rise out of the Lisbon trough until at Smithton, the coal rises out of water and is opened at the *Smithton mines* (Waverly Coal and Coke Co.) just at the station. There is an extensive operation here, coking all their nut and slack coal (7000 to 8000 bushels a day) which after washing, passes to a plant of 117 ovens.

All the front coal along the river is still untouched, developments having been started on the rear outcrop which, as already stated, crops near Lee's mill in the creek, only about a nile from the river.

There are two distinct operations in this valley, distinguished as *New* and *Old Hill workings*, or Smithton No. 1 and No. 2. The pit mouths are respectively 800′ ± A. T. (level of coal). The former lies on the south side of the creek, and the property owned there is fairly well mined out, being a block of very regular coal, worked by a series of butt entries extending south-east with the rise of the coal, from a rather sinuous main (face) entry, driven to the south property line on water level.

The present workings (Aug. 1886) in the old hill are in about 7000 feet from the pit mouth along a face entry, driven north-east and driven so as to keep just above water level. All the front coal to the dip is still undeveloped, and will probably be shafted upon along the river front. An elaborate system of wire rope haulage is in use here extending to a parting inside the mine, 4,500′ long. The coal pillars are designed to be about 125 yards thick. Butt entries are driven double with a rib 25 yards thick between, cut through every 200 feet.

The rise of the coal to the south-east is marked. There have been no swamps so far met with, and only once an abnormally rapid dip, where the coal is wet and too steep to be worked with safety.

The breast coal is quite variable, and is said to yield from 6 to 8 feet of coal; but I should judge 5′ 6″ to be an average thickness throughout the mine. The brick coal 10″–1′ is usually sent to the coke ovens.

The *Redstone coal* ("4′ bed") is seen back of the tipple about 60 feet above the Pittsburgh. The mine yields about 66 per cent. of lump, and the output in 1885 from both openings reached 60,000 tons. The mine tracks run for several hundred yards up the creek from the tipple before entering the mines.

About ¾ miles below Smithton, the *Pittsburgh coal* rises from the river, and about 1 mile north of Jacobs creek, is opened at *Eureka mine* (Stoner & Co.) in a small ravine at 800′ A. T. The coal here is about on the same level as at Smithton mines; at least no difference could be detected by barometer. The pit is about 200 yards east, up ravine, from B. & O. R. R. track, where there is a plant of 20 ovens, idle in Sept. 1886. The mine is opened on single entry, working to the hill north of the ravine. The old main entry has a irregular course, always keeping just above the water line and is in about 2000′ to entry Nos. 7 and 8.

The face entries run southward from this,—all single. A great deal of the front coal has been taken out here, and the present entries are led back through old workings. The outcrop of the coal rises going up the stream about as fast as the creek; but on the river, at the tipple, it is still 15′ beneath the surface, and does not come out along railroad for some little distance south. All the coal dips north-west to Port Royal.

About ⅔ lump coal are won from the mine's output here, and mining is done *above* the bands at present, obtaining about 5′ 3″ of first rate coal. The output of the mine for the year 1885 was 8,424 tons. To the south, the coal soon rises above the B. & O. R. R. track and the Barren Measure rocks outcrop to Jacobs creek, and extend up the stream for 1½ miles, until about 2 miles from the river the *Upper Freeport coal* is mined 3′ to 4′ thick and of good quality, brought up by the Fayette axis, 1 mile further east.

Rostraver township is an outlying area occupying the extreme south-western corner of Westmoreland Co., lying between the Monongahela and Youghiogheny rivers. It is *geographically* more a part of Allegheny Co. than Westmoreland, though its *geological* position is such that such a transfer of boundaries will probably never be made. Whether the character of its soil or its underground wealth be considered, this county is destined to be of importance, for its mineral and agricultural productions have unrivalled avenues to market. These are now almost sufficient; and as a Monongahela shore line railroad must certainly be constructed in the near future, the only drawback to its rapid development will then be removed.

This township possesses an uninterrupted outcrop of the *Pittsburgh bed* along its western line from Bellevernon to below Webster, tributary to Pools No. 3 and 4. But while the presence of the *Waynesburg anticlinal* through this portion of the township (passing north-east from a mile below Bellevernon to and beyond Webster) has somewhat retarded the development of its valuable coal by producing structural features which increase the expense of mining at each additional mile from the river, the position of the *Lisbon synclinal* at Port Royal on the Youghiogheny river has more than equally favored more than five-sixths of the county, and brought about such structural advantages as will have telling effects in the future growth of the mining industry when once fully started on the Youghiogheny side. Here however the *Pittsburgh coal* is for the most part deeply buried in the trough of the Lisbon basin, and the increased expense of mining it there by deep shafts does not seem to be warranted as yet, even by the increased facilities for economical working after such shafts are constructed.

The *Waynesburg axis* may be said to have reached its zenith on the Monongahela at Bellevernon. The *Pittsburgh coal* on its arch here approximates 1000′ above tide. At Waynesburg, far to the south-west in Greene Co., also on the crest of this axis, the *Waynesburg coal* passes over its arch at 940′ A. T., placing the Pittsburgh bed at about 580′, or a fall between the two points of about 400′. North-east of Bellevernon, the same *Pittsburgh bed* lies on this axis at 900′± A. T. at Webster and rides gently over the arch on the Youghiogheny at 835′ A. T. This forcibly demonstrates the rapid subsidence of this great arch both ways from Bellevernon.

At Port Royal, less than six miles east of Webster, in the Lisbon basin, the *Pittsburgh bed* is only about 600′ A. T. or 300′ lower than at Webster. This tells the whole story and indicates what a vast field of coal awaits development in this township where the structural features present the most favorable aspects for mining upon the rise of the measures.

Along the river the facilities for shipment by the Monongahela Navigation Co. have lead to a number of developments; but with few exceptions they are not very extensive.

The *Becket's run mine* (Bank of Commerce) is the first south from the Allegheny Co. line, at about 805′ A. T. This was not in operation. The coal dips strongly north-west down river, showing 25′ lower in 165 yards, at the mouth of the old pit mouth.

Four more inactive operations have opened the crop going south, known as the *Bakertown*, *Paynetown*, *Heslep* and *Bissel mines*; the coal rising about 75 feet to the last opening, where it approximates 880′ A. T.

The *Gilmore mine* (North Webster Coal Co.) is the first important operation, situated about ¼ mile north of Webster at 900′ A. T. This mine is developed on the single entry system.

The main gangway is driven, quartering the coal, about N. 72° E. In about 300 yards this entry forks, the true face entry being driven from here N. 24½° E. 500 yards long, and forming the present main entry, and the butt entry driven S. 66½° E. 550 yards to the outcrop in Webster's hollow. This rear outcrop extends some distance up both branches of Webster's hollow, and two more butt entries of the Gilmore mine are extended to it.

All the front coal is worked out, and in August, 1886, about 98 acres of coal remained untouched out of the original 200 in the property. Butt entries are driven 150 yards apart and the rooms 75 yards long.

At about 100 yards from the pit mouth, the main entry enters a closed *swamp* about 21 feet deep, and keeps in it for 200 yards to the forks of the entry. This swamp has a circular shape and no apparent drainage outlet; but the present workings are far to the rear of it now. In 200 yards along the main face entry another smaller swamp is met, and all the water collects here, at No. 5 entry, and is syphoned out of the pit mouth.

The coal in Webster's hollow is about 910′ A. T. and all dips N. W. *into* the mine. Some of the coal in the front hill was drained into a small ravine down river to the pit mouth.

The two swamps are the only serious difficulties that had to be overcome, and as is usual they begin to develop themselves as the axes are approached. A general section seen in the mine gives :

Roof coal, ...	1′ to 1′ 4″
Main clay, ...	0′ 8″ to 10″
Breast coal, ...	4′ 1″
Bearing-in, ...	3″ to 4″
Brick, ...	10″
Lower bottom, ...	1′ 2″

The entire roof division is about 3′ thick and the breast coal sometimes thins to 3′ 6″. Bearing-in is done above the bands, leaving the brick and bottom coal in the mine. The output in 1885, was merely nominal, the mine not being in active operation during that year.

Webster mine (J. & W. C. Guffey) is the next operation, situated south of Webster and Webster's hollow, and opened on the river bluff at 910′ A. T.

The *Waynesburg axis* passes through these workings. The old main entry entered the front hill, and this part of the mine was drained into Webster's hollow.

At present a long surface road extends from the river tipple (at the old pit mouth) to Webster, developing along the side hill, and extending almost a mile up the right fork of Webster's hollow, to the head of the crop. Here it enters the second hill, on the east side of the axis at 905′ A. T. The mine was not working when visited, and no one was apparently in charge.

Comparatively little mining had been done here since the mine had been newly equipped, and all the old work was done on the single-entry system. The lower division differs little from that obtained at Gilmore's mine.

The following general description of the plant here is taken from Report K.[4] p. 53.

"The coal is hauled from the pit mouth (when the mine is in operation) on a short outside road to the check-house, where it is screened into a tram wagon having two compartments, one for receiving the lump and the other the dust coal. This wagon then runs down an incline tramway to the dust hopper, where it strikes a *knocker* that empties the dust coal, and the wagon then passes on to a sliding tipple at the river, where the lump coal is dumped into the boats. The slack is then let out of the hopper into a wagon underneath it which passes out on the slack road to another tipple where it is dumped into boats for its reception. A loaded wagon, in passing down the tramway from the check-house draws an empty wagon back up to the check-house again by means of a drum and line.

"This mine is worked on the block or single entry system. The main entry is driven through the front hill, a distance of 700 yards, to a branch of Webster run, where the road crosses over on a trestle, and the entry continues on into the second hill, to the head of the present workings, a distance of 500 yards more.

"The percentage of product when running is reported at 70 for lump and 30 for slack. *Horsebacks* and *clay veins* are rarely found and the *over clay* is quite thin, and in some parts of the mine it is absent."

The Barren Measures are fairly well developed along Webster's hollow and south along the river. The Connellsville sandstone (here shaly) and the Morgantown SS. are most conspicuous.

Another ravine south of the Webster tipple, cuts out the coal for half a mile back from the river, south of which ½ mile is the *Columbia mine* (J. T. Jones) opened 200'± above river or say 940' A. T.

The anticlinal passes close to this pit mouth, and may be closely connected with the swamp developed in the workings. The mine is opened on the single entry system. The main entry is driven on the butts, S. 67° E. Its estimate fall in the first 1000 yards is about 11′, and in August 1886 it had been driven 400 yards further.

A face entry is driven off this north-east at 1000 yards from the mouth. In 300 yards it passes into the bottom of a swamp, which extends from here almost to the pit mouth, and has a course of about S. 80° E.

From the bottom of this swamp the face entry is continued to an outcrop in the ravine north of the property, and raises 18′ in 110 yards. However, this represents an actual rise in the coal of only 13′± as the entry emerges in the roof coal. The swamp deepens from the pit mouth to the face entry.

Syphon pipes 2″ and 2½″ are laid here well into the swamp, and from the mouth of swamp 1050 yards of 4″ pipe syphons the water out into the north ravine. The drainage is very irregular, the field lying close to the dimpled arch of the anticlinal, and the roof is troubled through a large part of the workings by *horse-backs*, *clay veins*, and *swells* of all kinds. The coal section here is about:—Roof coal and slates 4′; Main clay 6″–10″; Breast 3′ 8″; Bearing-in 4″; Brick 1′, and Lower Bottom 1′ 4″.

Mining is rendered very expensive by the numerous irregularities in the bed at this point. It could have been more advantageously opened at the extreme head of the ravine to the north; and by a face entry south, get the benefit of the *rise* parallel to the axis as well as toward it to the west. The output of this mine in 1885 was 19,465 tons.

Iron City mine (Philips and Mitenzwyre) is situated in the next ravine to the south. The check house is placed on the river hill above the tipple, from which a surface road of considerable length runs around the hill top to the north-east, to the pit mouth at 950′ A. T.

The *Waynesburg anticlinal* lies on the other side of the river here, and all this coal dips directly south-east. The workings seem to have been entirely abandoned, and the pit mouth boarded up in Sept. 1886. A large amount of coal however, was formerly run out, judging by the immense dust heaps that have been dumped into the hollow below the pit mouth. The main entry is on the butts, and the mine was worked on single entry system, face entries 150 yards apart, and working butt entries 160 yards. The main entry dips south-east 60′ in 1210 yards to the pumping shaft 130′ deep, or from 25′–30′ per mile, and this is not the *line of greatest dip*.

From this mine the river commences to curve westward, and soon passes to the western side of the anticlinal. The measures begin to fall gradually towards Lock No. 4. The outcrop here is quite strongly indented by numerous short ravines, but not opened at all, although advantageously situated for attack from the north side.

Rounding the point, and just above Lock No. 4, the *Rostraver mine* (Mr. Schrader) is opened at 938′ A. T., or 200′ above Pool No. 4. The incline from the check house to the river tipple is 218 yards in length.

The mine is opened on double entry system, the main entry being half face and half end, though rather inclining towards face. This entry dips for 600 yards very gently to a small swamp 3′ deep, beyond which the coal is quite level. There is now a gangway along the swamp south-west to drain water out to the south crop. The old workings drained to the north, there being a slight fall in that direction along the face entries. The new main entry turns on to the butts at 150 yards from pit mouth, and *rises* in that direction 11′ in 1400 yards. A section of the bed here shows, in dirt gangway:

Sandrock.			
Coal,		7″	2′ 8″±
Slate,		2″	
Coal,		4″	
Slate,		5½″	
Coal,		7″	
Clay slate,		1″-3′	
Coal,		9″	
Main clay,	1′	4″ to 0′ 2″	
Breast coal,	3′	5″	5′ 8½″
Bearing-in,		3″	
Brick,	1′	2′	
Bottom,		10′	

Only the breast coal is mined here, and looks well, and is in places thicker than the above measurement. One-fifth of the output is slack and nut, over 1¾″ screen.

The measures still rise going up river to Gibsonton where the Waynesburg axis crosses, and from there the coal dips to Bellevernon. The Morgantown SS. shows 15′—20′ thick under the arch of the axis.

Along the Youghiogheny river the developments at West Newton and Port Royal have already been spoken of in connection with South Huntingdon township geology. The coal crops along the river for a little over a mile north of the Fayette line.

The Upper Productive measures spread through a greater part of this township, and a limited area of the Upper Barren measures occurs west of Rostraver P. O. Their coals and limestones are quite fully described in Report K. K., and do not warrant repetition here.

The character of the coal along the Youghiogheny river is shown in the following section:

Roof division,		3′
Main clay parting,		1′
Lower division,		8′ 8″
Breast *coal,*	6′ 2″	
Bearing-in *coal,*	6	
Brick *coal,*	1′ 0″	
Lower bottom *coal,*	1 0′	

The bearing-in is double here and the breast coal occasionally carries a thin band of slate at 15″ from bottom.

CHAPTER IX.

Fayette County.

Fayette Co. occupies the same relation, geographically and geologically, to Westmoreland county, as Greene Co. does to Washington Co. on the west side of the Monongahela river. Indeed, but for the north-east and south-west trend of the rock measures, diagonally across these counties, each pair of counties would present geological features parallel to the other. Fayette county contains 830 sq. miles in round numbers, and in the census year 1880 sustained a population of 58,842.

Whether from its almost unrivalled coking coal fields, contained within the Blairsville basin, from Jacob's creek to Uniontown and Fairchance, without a break; or from its vast and practically untouched gas and steam coal territory held within the Lisbon trough, between the Youghiogheny and Monongahela rivers, this county, or at least its western half, is destined to become a vast supply station from which thousands of tons of high grade fuel wealth are to be distributed far and wide, to meet the wants of distant communities. On the north side it has Jacob's creek for a common boundary with Westmoreland county, and on the west a magnificent water front along the Monongahela river in common with Washington and Greene counties. Southward it is bordered by the States of West Virginia and Maryland, while on the east the upper Youghiogheny and Laurel hill divides it from Somerset county.

Geologically it is a south-westward extension of Westmoreland Co., the same basins and anticlinals existing here, along the same lines and ridges, *always* with the distinction that the south-westward sinking of the rocks has caused to be retained much larger areas of the upper rock groups than was the case in the more northern county. For this reason a much larger outspread of the *Upper Barren measures* is shown, by the map-coloring, to exist in the Lisbon trough in Fayette Co.; and even in the shallow Blairsville basin, south of the Youghiogheny; remnants of these upper coal measure rocks are still left to mark the former outspread of the group throughout this basin, and testify to the well sustained law, deepening these basins *going south-west*, so frequently referred to in this report.

To the east of the *Blairsville* (Connellsville) *trough*, both Chestnut ridge and Laurel hill exist, presenting the same strong contrast in their topography and geology to the anticlinal ridges further west, and showing a marked deflection in their course towards the south, approaching the Youghiogheny. East of the Blairsville basin, the whole country is stripped of the *Pittsburgh coal* and all higher measures. The Lower Productive measures and the subcarboniferous rocks spread widely through fully one-half of the county, not otherwise occupied by the Barren Measures.

The *topography* of the district is as plainly marked and as strongly accented here as in Westmoreland, for nearly the same ridges traverse both counties.

Brush ridge, running nearly parallel with Chestnut ridge to the east, rises near the West Virginia line and extends in practically a straight line north-east into Westmoreland Co., its crest being about 8 or 9 miles west from the larger ridge.

To the east of it lies the Blairsville coking coal basin, in a valley, between the two ridges; but high ground. To the west, the Lisbon trough, a generally rolling and beautifully molded country; except along the Monongahela and the larger streams which cross it, where the topography is bold and precipitous in places. Brush ridge itself, is a broad flat arch here, not so prominent as it becomes north of the Youghiogheny, and while showing areas of the Lower Productive measures on the river and the Redstone creek, under the arch which created it, sinks so gradually to the south-west as to permit the *Pittsburgh coal* and higher measures, to ride over its crest at Morris cross-roads and south of the Cheat river.

It is evident from the map, that the Lisbon trough to the west is much deeper than the Blairsville basin; and as a consequence, the *Pittsburgh coal* is inaccessible through a large portion of the basin, except along the eastern rim.

The *drainage* of the county, except for a portion of Wharton township, along the Virginia line, is entirely collected into the Monongahela and Youghiogheny river basins, within the county's border lines. Jacobs creek on the north, drains all that portion of the county north of the Youghiogheny and west of Chestnut ridge, not drained directly to the river, and comprising largely the townships of Connellsville, Bullskin and Tyrone.

The *Youghiogheny river*, west of Chestnut ridge, receives a score of streams from the south, such as Dunbar, Opossum, Dickinson Mill, Furnace, and Virgin's runs, draining Dunbar and Perry twps. East of Chestnut ridge its tributaries drain Salt Lick and Springfield to the north, and Stewart, Henry Clay and a part of Wharton, south.

Redstone creek is an important stream, entering the Monongahela just below Brownsville; its source being on2the flank of Chestnut ridge in South Union twp. Before entering the river it receives Coal Lick, Jennings, and smaller streams from the south, and Bull, Boland, Allen and Crab Apple from the north, thus collecting the water, in parts or the whole of six townships, and furnishing the natural gateway for the Redstone Extension of the P. V. & C. R. R. from the Monongahela river to a junction with the S. W. Penn R. R. below Uniontown.

Dunlap's creek is a similar and nearly parallel stream, though not so long or so large, rising in the Brush ridge, back of New Salem and flowing west, between Redstone and Luzerne townships to the Monongahela river at Brownsville.

The *Monongahela river* takes up all the drainage of the west side of the county though it receives, in order, northwards from the Virginia line, several important tributaries, to wit:

1. *Cheat river* entering at Point Marion.

2. *Georges run*, which with its York run branch, drains all Georges twp., and largely Spring Hill and Nicholson.

3. *Jacob's creek* and *Cats run*, both smaller tributaries further north, but only draining Nicholson twp.

4. *Brown's run* entering the river in Pool No. 6 below Masontown, forking about 1½ miles from the river, with its North and South branches.

5. *Middle creek*, still further north, mostly drains German twp. Various other insignificant streams enter the river on its way to Westmoreland Co.; but they are small and short, and are of little consequence in framing the topography of the district.

The *transportation facilities* of the county are exceptionally good. Although the P. V. & C. R. R. (Monongahela Division of the P. R. R.) extends south only to Brownsville, and on the Washington county side, yet the Monongahela slack water navigation extends well into Virginia, the last lock, No. 7, at New Geneva being well under course of construction, and thus providing a cheap and abundant outlet for shipments from all the western side of the county.

The Redstone Branch R. R. has already been mentioned as extending 16½ miles long from Brownsville Intersection to a junction with the S. W. Penn R. R. The latter road, a Pennsylvania branch line also, extends north-east along the eastern edge of the basin into Westmoreland Co., and south-west to the Fairchance Iron Works, looking to an ultimate extension into West Virginia.

The B. & O. R. R. and P. & L. E. (P. McK. and Y.) R. R. have lines up the Youghiogheny, the former going on south-east through the county to Cumberland and the latter having its terminus at New Haven, opposite Connellsville. All these lines are large carriers of coke; but little coal is shipped from this region at present, very few of the river mines even being actively worked for some time.

The *structural features* of the county are quite as plainly marked as are those of Westmoreland.

The *Laurel hill* and *Chestnut ridge* anticlinals are continuous through those ridges to the West Virginia line, and bring up the same series of the sub-carboniferous rocks on their crests as in Westmoreland Co. Particularly fine sections of these rocks are exposed in the gaps of the Youghiogheny river.

It is important to note the fact here that south of that river the Chestnut ridge of the north becomes the Laurel hill through southern Fayette, and this identity is emphasized although both these eastern axes lie far to the east of the district germane to this report.

The *Blairsville anticlinal* of Westmoreland Co. seems certainly to be identical with the *Fayette axis* of this county, for while the former can not be traced with accuracy far south of the Penna. Railroad, owing to the presence of the uncertainly identified Barren Measure rocks, spreading over the district north of Jacob's creek, an extension of the axis south-west to that creek passes through an area of the Lower Productive rocks, uncovered by the erosion along that anticlinal.

Here, following the example of the greater anticlinal flexures, further east, its course becomes more southerly, hoisting the measures in a pretty well defined arch above Layton station on the B. & O. R. R., strikes along Virgin's run, crosses west of Flatwood P. O., and reaches the Redstone creek at the village of Upper Middletown, where it again brings up the *Upper Freeport* coal and Lower Productive measures; strikes the National road in the broad flat hill 3 miles west of Uniontown, and just west of the school house on that summit; touches George's creek near Crow's mill; passes west of Morris cross-roads and thence south-westward into West Virginia a short distance above the mouth of the Cheat river.

The axis is a very important one, commercially separating the distinctly coking-coal field from the more strictly gas-coal region and limiting, on the east, the special district of this report, described as the *Pittsburgh Coal region.*

Considerable time was spent upon that portion of Fayette Co. lying between the Redstone creek and the State line, in the endeavor to definitely locate the course of this axis. And the numerous tide levels shown on the map have already been used in Chap. III. as the basis for placing it where it approximately belongs. It is by no means a straight line, and its deflection southward is probably more strongly marked in this county than elsewhere in the district.

The *Waynesburg axis* lies entirely west of, and outside this county, on the west side of the Monongahela river.

The two important synclinals in Fayette Co. are

1. The *Blairsville* (Connellsville) basin lying between the Chestnut ridge and Fayette (Blairsville–Indiana) anticlinals, and

2. The *Lisbon basin* lying west of the latter axis along the east side of the Monongahela river.

The former basin forms no part of the *Pittsburgh Coal region* proper, being a distinct field of itself, the depository of the typical coking coal of America, whose coal reaches a very different market and is used for a different purpose than that from the basins further west.

The *Lisbon basin line*, in Fayette Co., enters Washington township from Port Royal on the Youghiogheny river. It is apparently double here showing two sub-basins in Jefferson township. The eastern division passes to Redstone P O. on Little Redstone creek in Jefferson township. Curving southwards slightly, in consonance with other flexures already mentioned, it reaches Redstone creek near Parkhill's mill; Dunlap's creek about a mile below the Menallen township line; Middle run, in German township, about a mile from the river, and crosses the Monongahela about a mile above that creek and thence through Greene Co.

The western sub-division crosses through the north-west corner of the township and reaches the river below the Climax mine. The synclinal as a whole is an exceedingly deep trough, *i. e.*, holds within its fold a larger covering of the higher coal measures than any other basin of the district; and owing to the very gradual and gentle rise of its floor north-eastward, it carries these upper measures much further to the north. It is with this basin and its different rock systems that this report has mainly to deal, supplemented, of course, with a description of its eastern flank, along the crest of the Fayette anticlinal.

Stratigraphical Geology. A treatment of Fayette Co. under this head is simply a repetition of the statements already made concerning Westmoreland Co., with only this essential difference viz:—the greater general depth beneath the surface of the *Pittsburgh coal bed*, and consequently the greater covering of the Upper Productive and Upper Barren measures contained here, both due to the same law governing the entire district—the *law of the south-west sinking of all the groups of rocks* from the north into the State of West Virginia.

The lowest rocks exposed in this county (pertaining to the Pittsburgh Coal Region proper) are the upper members of the Lower Productive (Allegheny river) series, brought up by the Fayette axis on Jacob's creek, the Youghiogheny and the Redstone.

The highest measures are contained within the Lisbon synclinal and consist of the Upper Barren measures, held there without interruption from the Redstone to the river, and occurring in patches to within 2 miles of the Westmoreland county line.

The Upper Barren Measures.

The full generalized section of the two groups of rocks making up this series have been given in Chap. IV. They attain their greatest development in Greeene and Washington counties, from where they were named.

In Fayette county, the upper or *Greene Co. group*, has nowhere been identified, and it is fairly demonstrated that the highest summits in the Lisbon basin have lost all remnants of this group.

The lower, or *Washington Co. group*, is present in its entirety, though exposures, in the main, are unsatisfactory and sections incomplete.

The *Upper Washington Limestone No. VI*, the top member of the group, can only occur in the high hill tops, north from the National road, in Redstone township.

Prof. Stevenson likewise identified the *Jollytown coal bed* some 40 feet lower, on the National road, west from Mr.

Colley's residence, and on the ridge nearly a mile northeast. Here, as in Westmoreland, Limestone No. IV of the section is conspicuously absent, and Limestone No. III was only identified in Redstone township at two localities on the National road; at the election house and near the synclinal, in a hollow west from Mr. Colley's house, and it is quite ferruginous.

The *Lower Washington Limestone* No. II, capping the *Washington coal* occurs in German township, on Mr. Struble's property, and in Redstone township, on Dunlap's creek, above Merrittstown.

The *Washington coal bed* has a considerable outspread in this basin, having been identified in German, Redstone, Luzerne, Jefferson, and Washington townships. At Strubles, in German, it is 5′ 8″ thick in four benches, 0′ 4″, 1′ 1″, 0′ 11″, 1′ 2″ thick, separated by three clay bands, 1′ 3″, 0′ 6″, and 0′ 5″ thick. Between it and the overlying limestone there is a deposit of carbonate iron ore at this locality, but lean and of no importance throughout the basin.

In Redstone township the bed was once opened on Dunlap's creek, at Mr. Gribbles, reported 7′ thick, in four layers of coal separated by clay partings. The coal can be traced to Mr. Hibb's place, where it was formerly opened under the road soon passing to the bed of the creek, into the Lisbon synclinal, which crosses about a quarter of a mile below the house.

In Luzerne township it occurs just beyond Heistersburg, and in Jefferson, at the school house, on the road to the old paper-mill on the Redstone. Also, in high summits near the cross-roads 2 miles north from the Methodist church on the road leading from Parkhill's mill to Redstone P. O. It is here 7′ to 8′ thick with the usual destructive partings.

In Washington township, it occurs only as a blossom on the Red Lion road at 500 feet above the Monongahela river.

The Little Washington coal and *Limestone I* "*b*" are wanting, and *Limestone I* "*a*" was met with near the Christian chapel, on the National road, east of Brownsville, and on

Dunlap's creek above Merrittstown; but nowhere else in the county.

The *Waynesburg "a" coal*, always thin, is still very persistent throughout the trough. It was seen in various places in Redstone, Jefferson, and German townships in this basin; sometimes associated with Limestone I "a" capping it; but too insignificant to warrant specific locations.

The Upper Productive Series.

This series is more than usually important in this county and basin, for in addition to the presence of the ever persistent and valuable *Pittsburgh bed*, almost every other bed of the series attains workable thickness at different localities, and thus adds to the economical wealth of the district. While none of them are to be compared in value to the bottom member of the series, in many places their presence, in good shape, is of great service and benefit to the community.

The *Waynesburg Sandstone*, the top of the group, outcrops in every township from German to the Westmoreland Co. line, from 50 to 75 feet thick, usually massive though sometimes flaggy on top, and making a high grade building stone.

The *Waynesburg coal bed* is quite as persistent as the massive sandstone cover above, which has preserved it. It is the principal source of supply to the farmers in German, Luzerne, Brownsville and Redstone townships, and sparingly exposed, thin and worthless, in Jefferson, Washington and Menallen townships. The bed is usually triple; shows sudden fluctuations in thickness and throughout is mainly serviceable for country bank mining.

In German township, this coal shows along the road from Masontown to McClellandtown, before reaching the first forks, and has been mined by Mr. Hoover near here showing three benches of coal, 16″, 26″ and 30″ thick with intervening variable clay bands. The coal is high in ash.

It is again opened at Mr. Gilmore's, on the McClellandtown road, with a total thickness of 7′ 4″, with about 5′ of coal. Near Johnson's saw mill on the Heistersburg road, it has been stripped, and at Haney's opening, below the school-house, shows its triple character again. The interval to *Washington coal* is 150′ ±.

In Luzerne township, which lies wholly on the western side of the Lisbon basin, the *Waynesburg coal* is available throughout. Along the river the bed is opened at a multitude of places, as far north as opposite Ten Mile creek, and shows a very fair grade of coal, everywhere about 350′ above the *Pittsburgh coal* , which bed is here under water level.

At Wood's bank it is 240′ above the river and a mile S. W. of Heistersburg shows coal benches, 3″, 2′ 0″ and 3′ to 4′ and clay slates 3″ and from 2″ to 10″ thick intervening. Its character is further shown by an opening on the Telegraph road, ¾ of a mile from the river where a parallel structure shows coal 1′, 1′ and 3′ separated by clay 2″ and 2′ to 10″.

A score of other openings occur in this township on Dunlap's creek, at Merrittstown ; on the Telegraph road 2 miles from Merrittstown ; on the Heistersburg road, etc. ; but no new features are brought out at these places.

In Redstone township this bed shows in the divide between Dunlap's and Redstone creeks ; at Norcross' opening on the Brownsville road, leading from Parkhill's mills where it shows coal 4″, 4″, 1′ 8″, 2′ 5″ separated respectively by clay slate and shale 5′, and clay 2″, Bone coal 4″ and clay 2″ to 6″.

It crops along road towards the Baptist church and beyond to within site of the National road, and opened by Mr. Lancaster and Mr. Price as follows : (Rep. K K p. 229.)

Coal and clay, ...	1′ 2″	2′ 0″
Clay, ...	2″	2″
Coal, ...	2′ 2″	2′ 1″ to 1′ 8″
Clay, ...	3″ to 10″	1′ 3″ to 0′ 4″
Coal, ...	2′ 4″	2′ 4″

On a road leading south from the National road to Dunlap's creek the *Waynesburg coal* is again opened at Garwood's mine, with 14, 22 and 18 inches of coal, and intervening clay 2 and 11 inches thick ; the same at Braithwaite's opening. Brashear's bank, a mile east and near the pike, varies some little in the bottom members. Two miles south from Garwood's, and on the upper Dunlap's creek, the coal has been mined at Craft's and Armstrong's 6′ to 7′ thick with two partings and three benches of coal.

At E. Vankirk's, a mile up the creek, it shows 7′ 8″ thick with 5½ feet of coal and finally again a mile further up at Vankirk's second opening, where the coal is partially cut out by a serious sandstone horseback between the upper and middle benches. All these records sufficiently show the character of this coal, so largely mined in this township, though for strictly local use only. It suffers greatly in comparison with the Pittsburgh bed, both from increased impurity, volume of ash, clay partings and expensive mining. Northward it thins, and it is not possible to give its bed section in the townships north of the Redstone.

The *Little Waynesburg coal bed* some 20 or 25 feet lower in the section, is frequently a well developed *coal bed* in the Lisbon trough, but quite thin. It is 2′ thick on Brown's run and somewhat thicker near Parkhill's mill on Redstone creek.

The *Waynesburg limestone*, below it, is quite persistent and noticeable in this part of the district, occurring largely in west and north-west German, 35′ thick in the Brown's run territory. In Luzerne it shows 8′ thick, and only 4′ in Washington. On Redstone creek it again thickens from 15′ to 20 feet and again becomes reduced in Jefferson and Washington. It yields a superior lime and is therefore much sought after by the farming interests of the region.

The *Uniontown coal* is present throughout the basin, but it seems every where thin and valueless; of irregular thickness and generally impure. It rests directly upon the upper division of the Great Limestone formation, and is therefore somewhat of a guide to better things above and below. Its chief development is at Uniontown, where it is a double bed somewhat more than 3 feet thick; but necessarily pales before the magnificent development of the Pittsburgh bed at this point.

The *Great Limestone formation.* In this county, as in Westmoreland (where it has suffered still greater degradation), this great calcareous formation has lost much of its massiveness, especially its lower division, which is greatly subdivided.

The *upper division*, in the Lisbon trough, is a very conspicuous rock throughout Fayette Co. occurring everywhere except in the two southern townships, Nicholson and Spring Hill. It is quite variable in thickness and quality, and in the vicinity of Brownsville seems to be entirely absent.

Between this and the lower division there is a sandstone, varying with the increase or decrease of the lower division, and occasionally becoming quite shaly.

The *lower division* attains its greatest thickness in this trough and is everywhere persistent and readily recognized through the fertile hills which it underlays.

At Brownsville this rock is fully 70 feet thick; on the Youghiogheny 55 feet and diminishing northwards.

In whole or in part, the *Great Limestone* is well displayed on Downer's run in Washington township, below the Red Lion road; and the upper or Uniontown division shows on that road, 45 feet below the *Little Waynesburg*.

In Jefferson, along Redstone creek, the lower division shows in the stream along the Franklin township line, the rocks descending towards the old Parkhill mill, where the Uniontown division shows on both sides of the synclinal.

The lower division is again splendidly exposed on the left hand fork 65 feet thick; and again with the upper division, at the Redstone post office, where it is in the creek, at the north fork.

The *Uniontown division* remains constantly in sight along the road to Perryopolis. Both limestones are prominent features of the river topography, especially the lower, fully 90 feet thick.

Imperfect exposures also occur in various parts of Redstone township, while in Luzerne, adjoining, along the river bluffs it is 70 feet thick. It is 60′ thick on Bull run, about 30 feet above creek level and separated from the *Uniontown coal* above by 40′ of sandstone and limestone. Finally in German township, good exposures take place along the upper part of Cats run and from thence continuously to the village of Masontown.

The *Sewickley coal bed* comes next beneath the formation just briefly described. In the southern part of the Lisbon trough it is 120 to 140 beneath the *Uniontown coal* the interval being largely occupied by the Great Limestone members. Here too the bed attains a good workable thickness and is known as the "5 Foot Vein", and is a very persistent bed.

In the extreme southern end of the basin it is only about 1 foot thick. Between it and the base of the Great Limestone, there occurs, in Spring Hill and Nicholson townships, from 25 to 40 feet of shaly sandstone, the coal itself resting almost immediately on the Fishpot Limestone. Northward the overlaying shale becomes very thin in this basin.

It has a greater development in Springhill and Nicholson townships than elsewhere, being thicker and of good quality. In the former it is about the highest member of the Upper Productive measures exposed; and is largely confined to the highlands in the centre of the township.

The *Pittsburgh coal* is brought well up to the hill tops here too, brought up by the Fayette anticlinal; so that the *Sewickley bed* is not as largely opened as its size would warrant.

In Nicholson township, to the north, the Fayette axis occupies the eastern side, so that the larger part of the township is in the Lisbon basin. The *Sewickley coal* is 60′ to 70′ above the Pittsburgh, with which interval its position can be readily located through the township by means of the many openings on the Pittsburgh coal.

At McClellandtown, in German township, the *Sewickley coal* is exposed in the road, and remains in sight for a mile east of the village, resting on the Fishpot limestone. In Luzerne, Redstone, Jefferson and Washington the bed becomes thin and shaly and commercially unimportant. The *Fishpot limestone* is a fairly persistent stratum rather closely allied to the overlying Sewickley coal bed. Towards the south these two members are separated by only a few feet of shale, and sometimes come together.

On Cats run, the interval becomes 15 feet; on Redstone creek, above Brownsville 30 feet; on the Youghiogheny 20 feet. The limestone is quite persistent all through the eastern side of the basin in Fayette County. At New Geneva, on the Monongahela river, it is 10 feet thick, and quite ferruginous. On Redstone creek it becomes 30 feet thick and much of it is of excellent quality and largely burned. This too is its character in German township.

The *Redstone coal bed* is a readily located stratum throughout the entire Lisbon basin in Fayette, and occurring between the *Sewickley* and *Pittsburgh* beds it is persistent with them, either as coal or a rich carbonaceous shale far north of the Pennsylvania R. R. in Westmoreland Co. It can hardly be called a commercial bed, either from its size or character, although it is considerably mined for local use, where the Pittsburgh coal is not accessible. It rarely shows more than 2 feet of *coal* in Fayette, except possibly in Washington and Perry townships.

The interval to the *Pittsburgh coal* varies excessively in this county. Under the coal, the *Redstone limestone* is present, of good thickness and pure, from the Redstone to the Youghiogheny, though patchy and uncertain.

In the Lisbon trough the interval just mentioned is only 25 feet at New Geneva, filled by sandy shale; about the same on Cats run and at Brownsville, though of a harder character. The position of the *Redstone coal* can be more conveniently located in reference to the detailed description of the Pittsburgh coal by townships, to immediately follow.

Township Geology.

Washington township lies along the Monongahela river, south of Rostraver township of Westmoreland Co., with Perry on the east and Jefferson on the south. It is wholly within the Lisbon basin, which crosses its southeastern corner, including a small area of the Upper Barren measures in its trough.

The section extends from the *Washington coal* bed of that series to 175 feet below the *Pittsburgh bed.* The Barren Measure group is confined solely to a strip along the river bluff, and a narrow tongue along Little Redstone creek, dipping south-east towards the Lisbon synclinal.

Bellevernon city occupies its extreme north-west corner, about a mile below which place the *Waynesburg anticlinal* crosses the Monongahela river from Westmoreland into Washington Co.

At Bellevernon, the *Pittsburgh bed* lies high in the hill above the town at about 850′ A. T., and various openings, the old Fremont, Taggart, Speers and Glass Works' mines, now abandoned, mark its outcrop to the south. The hills around are largely cultivated and farmed.

The Barren Measure red rocks are lifted well up the hillsides along the river bluff, sinking slowly southwards.

The *Little Pittsburgh mine* (Schmertz & Co.) is the first active operation south of Bellevernon, and is opened about 100′ above the river at 835′ A. T., in Pool No. 4. There is a small plant of 9 ovens here, in which the slack coal is coked. Directly back of the ovens, the Pittsburgh limestone shows in a bed 3′ + thick, with a distinct north-west rise down river.

All lump coal—amounting to 45,600 tons in 1885—mined here is used at the glass works in Bellevernon, and the production of this coal has been somewhat curtailed by the substitution, in part, of natural gas.

The bed section here shows about as follows:

Roof coal,	0′ 2″	
Main clay parting,	0′ 10″	
Breast coal, block,	5′ 0″	6′ 5″
Bearing-in,	3″	
Brick and bottom, soft,	1′ 2″	
Limestone.		

It is claimed that 6½ feet of clean coal is mined through the greater part of the mine.

The dip is south-east and the mine drains into a hollow on the rear side of the hill. The main entry is on the face N. 25° E. and is about 300 yards long, on single entry.

No serious swamps or irregularities have thus far been noticed; but in a portion of the mine a heavy *spar* occurs in the roof coal, and along its course the *main clay parting* is absent, the roof coal resting directly on the breast coal.

The *New Tremont mine* (Jno. A. Wood & Son) lies a short distance further south at 823′ A. T., and about 1 mile from Bellevernon. The coal here is of the same general character, capped with a heavy slate.

The mine is worked on double entry, though the first hill was mined on single entry system. The main gangway (face) bearing N. 25° E. is 1500 ± yards to rear property line and shows coal at the pit mouth 7–7½ feet thick, though not so high inside the workings.

While there seems to be no distinct roof coal visible here, the top coal is very frequently inclined to be banded with slate and bony coal, and looks impure. The character of the coal mined, however, is excellent.

The Pittsburgh limestone is again well exposed here, about 3′ thick, on road leading down to pit, capped with gray slate and thin sandstone. The output in 1885 was 11,711 tons. Idle when visited.

No other openings occur between this point and Fayette city along the river; but the *Pittsburgh bed* is constantly in sight, and crops beneath the Cemetery hill in Fayette city. South of the town there are several openings to the Jefferson line.

The *Connecticut mine* is an abandoned opening just north of a small run marking the city limits on the south, and opening just below the public road at 780′ A. T. A section here gave:

Roof division,		3′ 9″
Main clay,		10″
Lower division,		6′ 4″ +
Breast,	4′ 10″	
Bearing-in,	3″	
Brick,	1′	
Lower bottom, concealed,	1′ ?	

Further up this small run, the *Redstone coal* has been opened 3 to 4 feet thick, and of excellent quality, and 40 feet above the Pittsburgh coal. The *Sewickley* occurs still higher up the stream 2′ 6″ thick.

The *Little Redstone mine* is opened just south of this stream in the point of the hill between it and Little Redstone creek. This mine was also idle. The pit mouth is

45 feet above the river or at 783′ A. T. The bed yields 7½ feet of coal, 1′ of bottom coal being left untouched. In 1885, 9,330 tons were mined here.

The outcrop of the *Pittsburgh bed* extends for some distance up Little Redstone creek, and is opened near the forks by Messrs. Stephens and Butler, showing a section as follows:

Shale on top,		10′	
Roof division,		8′	17′ 2″
Bituminous shale,	1′		
Shale,	5′		
Sandstone,	1′		
Coal,	1′		
Main clay parting,		1′	
Lower division,		8′ 2″	

The lower division is divided into seven benches by smal slate partings, the upper three forming the breast coal 3′ 9″. The bearing-in is double, and in all 5″; the brick and bottom benches are distinct.

Various other openings line this creek to the river, all showing about 7½ feet of workable coal.

The *Redstone coal* is also exposed here, 40′ above the Pittsburgh coal and 3′ thick.

The *Carondelet mine* (Carondelet Coal Co.) lies a short distance south of the creek, on the river bank, and opened at 786′ A. T. This is an old operation and in the past a large tonnage has been shipped from here. Recently it has undergone many vicissitudes and changes of management, and is at present (1886) worked upon a coöperative system. Nearly 200 acres of coal have been run out of this mine.

It is worked on double entry system, and only the coal *above* the bands (5′ 9″) is taken out. Beneath the breast coal, the bearing-in is about 3″ and the lower bench 1′ 2″ thick. The output in 1885 was 5,646 tons. This is the last opening in this township, the outcrop of the bed keeping close to the river into Jefferson township.

Jefferson township flanks the Monongahela river south of Washington, and displays an almost uninterrupted outcrop of the *Pittsburgh* bed along the river, disappearing beneath water level *only* in the trough of the *Lisbon basin*, which crosses into Washington county about 1½ miles below the mouth of Redstone creek.

The Monongahela river, in entering the township from the north on a nearly due south course, bends directly west for about 3 miles before taking up a generally south-east course to Brownsville or the mouth of Redstone creek.

The elevation of the outcrop therefore along the northern boundary line varies within narrow limits, showing at 786′ above tide on the Washington township line, and only 775′ at the point at Merchantville.

But between this point and Brownsville, the coal dips south-east to 720′ A. T. in the bottom of the western division of the Lisbon trough, rising again south-east to 780′ A. T. at the *Umpire mine* above the mouth of Redstone creek.

It is more than probable that the *Lisbon basin* is subdivided in this township by a subordinate anticlinal roll, as it certainly is in Greene Co. along Muddy run north-east of Carmichaels. But while the position of the western subbasin is very distinctly marked on the river, below Redstone creek, the eastern sub-basin can only be approximated owing to the *Pittsburgh bed* being deeply buried along its trough, and the higher Upper Productive and Upper Barren measures being unsatisfactorily exposed.

However the township, as a whole, is contained within the folds of this *Lisbon basin*.

The *Hall mine* (J. W. Hall & Son) is the first opening on the river, close to the Washington line, 48′ above the river and 786′ A. T. The property comprises several old country pits, whose openings are now partly boarded up and used as spring houses and cellar-ways in connection with the miners' houses, owing to the limited dwelling space along the river bluff. Everything was idle here in the fall of 1885.

The mine was opened on double entry system, the main entry bearing on butts south-east, 850 yards to Little Redstone creek under which it passes and extends some 400 yards further.

"The coal is only 18 feet under the creek (Little Redstone) bed at this place, and a considerable quantity of water flows into the entry through a *soot vein* which crosses the entry on a bearing of N. 20° E."(K^4 33)

The coal is lower here than at the pit mouth and the line of the sub-basin cannot be far from where the main entry crosses Little Redstone creek. As usual this leads to an irregularity in the workings.

The coal rises along the main entry 4′ in 300 yards; falls 9′ for 300 yards to the bottom of the first *swamp*; then rises 3′ in 200 yards and falls again 4′ in the next 200 yards to the bottom of the second *swamp* (and basin line) where it is 6 feet lower than the pit mouth or at 780′ A. T.

The bed section varies somewhat in these troubles. Near the pit mouth the following is exposed: Roof coal 8″; main clay 10″; breast coal 5′ 5″ to 6′; bearing-in 3″—4″; lower coal (not mined) 2′ 4″. Output in 1885 amounted to 23,800 tons.

The *Troytown mine* lies a little south-west from this at 780′ A. T., dipping into the hill along the main entry driven S. 38° E. for several hundred yards, and crossing the Hall mine swamp at about 800 yards in. This mine was also "out on a strike" and no information could be obtained. The breast coal yields about 5′ which, with the bearing-in coal, is all that is taken out. The bottom benches 2′ 6″ thick remain. Production in 1885 6,673 tons.

Several more abandoned pits (Furlong and Stimmel mines) intervene to *Bargėdde mine* (Luceyville Coal Co.) now abandoned at 776′ A. T.

It was opened on double entry, and shows 64″ of coal to the bearing-in 2″ thick, and with 2′ 4″ of coal in bottom, 9″ of which was left untouched.

Snow Hill mine (Alps Coal Co.) is next opened at 776′ A. T. immediately opposite Luceyville and 38′ above the river. Owing to the strike in the fall of '85, every thing was closed down and abandoned here, and no one could be found to furnish any information. The following facts are given by Mr. J. S. Wall in Rep. K^4 page 28, collected in 1881–1882.

"The mine is worked partly on the block and partly on the double entry system of mining. The main entry is driven against the faces or cleavage and crosses two *swamps*.

"The first swamp is 13 feet deep and the bottom is reached at 150 yards from the pit mouth. From the bottom of this swamp the entry rises 8′ in 200 yards, then dips 10′ in 200 yards and runs level for 40 yards more to its head."

These changes are no doubt due to the presence of the basin line to the south-east, although this mine is further away from it than any already mentioned.

The entire bed measures but little short of 8′ from the main clay to the floor, of which total about 2′ 6″ occurs *beneath* the bearing-in coal. This mine produced 46,690 tons in 1885.

Thus far along the river, and indeed as far south as the Redstone creek, the *Redstone coal* is occasionally exposed 2½ to 4′ thick of fairly good fuel; the *Sewickley* is generally absent, while the hills are not high enough to catch the Waynesburg.

The Great Limestone, both divisions, and the Fishpot limestone are the most marked features of the river topography, and are excellently developed here, 90 and 30 feet thick.

There are no openings in the *Pittsburgh coal* for 1½ miles west of Snow Hill in the narrow neck of land, as the several companies on the *south* side of the hill work forward to this north crop. The first of these is the *Merchant mine* (David Bowden) situated around the bend of the river, above Merchantville, at 772′ A. T. The coal is about exhausted here.

The *Little Alps mine* (Little Alps Coal Co.) adjoins on the south-east, and is opened at 770′ A. T. The mine was idle, by reason of the strike, when visited. The main entry is on face, and driven north-east for over 1000 yards towards the north crop. It rises all the way, the coal to the east of it dipping south-east.

The coal taken out of the pits here and in the vicinity averages from 4′ to 5′, down to bearing-in, and 2′ of coal left in bottom. The roof coal is 4″ to 6″ thick and main clay parting 12″ to 14″. The production of this mine in 1885 was 3800 tons.

Cedar Hill mine (Cedar Hill Coal Co.) is next south-east at 773′ A. T.

There has been a considerable development made here by this company, whose works were largely idle during the strike of 1885. Here the main entry is driven north-east nearly to the crop and rises all the way. To the south-east the coal dips sharply. The *main air course* is driven parallel, but about 1000 feet farther up the river. Butt entries are all driven single. A section of the bed at this mine shows:

Roof coal,	4″
Main clay parting,	1′ 0″
Breast coal,	5′ 0″
Bearing-in,	3″
Brick,	1′ 2″
Lower bottom,	1′ 6″

About six inches of the bottom coal is left in here. The production in 1885 was 25,914 tons.

Stony Hill mine (Stony Hill Coal Co.) is probably ¼ a mile south-east from Cedar Hill, and is opened at 757′ A. T.

Improvements were being made here at time of examination looking to the raising of the tipple and changes inside.

The entrance is by a short slope and the main entry is driven on face for 600–700 yards toward the north crop.

The mine had been worked on a combination of the double entry and block systems, and like the other properties in this vicinity, is advantageously situated for cheap development.

The axis of the sub-basin lies ¾ miles further south-east and no troubles of a serious nature are met with in this part of the field. The same practice in mining is pursued here as at Cedar Hill, and the coal presents a similar section. Output in 1885, 14,438 tons.

The Great Limestone outcrops in a bluff 120′ above the coal.

This is the last opening on the coal on the west side of the sub-basin, the bed sinking gradually beneath water leval to an elevation of *about* 720′ A. T.

The trough is quite narrow, and the river turning squarely south east after passing its axis line, the *Pitts-*

burgh coal soon begins to appear. It is first opened at the *Climax mine* (Climax Coal Co.) by a short slope at 738′ A. T. This slope is 160′ long at an angle of 14°.

The mine is worked on double entry system, and is well planned. The main entry and air course are driven parallel, on face of coal, with a 50′ rib between, and 200–300 yards long. The coal rises north-east along this entry.

The butt entries are driven double, with 25′ of coal between them. The left butts are practically level, but dip slightly into the adjoining synclinal. The right butts, however, driven up the river, *rise* perceptibly south-east.

Only the breast member is mined here, about 6′ thick, the balance of the lower division showing respectively 3″, 14″ and 15″. About 67 per cent. of the output therefore is lump coal, the screenings etc. yielding 33 per cent. of nut and slack. The quality is excellent and the product clean. The production in 1885 was 18.641 tons.

The coal rising south east going up river, is next opened at the *Albany mine* (Snowden & Hogg) at 748′ A. T.

Here too a slope is required to reach the coal and preserve facilities for tippling etc. This slope is 192′ long and strikes the coal at a vertical depth of 30′.

The main gangway (on face) was driven 200 yards into the hill when visited in Sept. '85, along which the coal was nearly level. Four double butt entries have been driven by this comparatively new company, who were mining back of the front hill old works, which has been dreadfully "grubbed" for the glass works.

A section here shows somewhat as follows, the roof coal being unusually large and pinching out towards the Climax mine:—

Roof coal,	1′ to 1′ 3″	
Main clay parting,	1′	
Breast coal,	3′ 3″	6 ″
Bearing-in,	3″	
Brick and bottom,	3′	
Limestone on bottom,	1′ 3″	

In the heavy mass of roof shales, about 30′ above the bed there is 12″ to 15″ of carbonate ore, weathered quite extensively along and back from its outcrop into limonite ore. It was formerly mined here on the long wall system.

The coal rises to 753′ A. T. at the old glass works and then extends about 2 miles up Redstone creek, going under water level at the first bridge above Linn station on the Redstone Branch R. R. It is opened at *Dean's pit*, just opposite Linn station, on the north side of the creek at 782′ A. T. or 30′ higher than at the glass works on the river.

It is here about 30′ above the creek, and as it very quickly passes beneath water level just above the station. the sub-axis dividing the Lisbon basin must pass somewhere near.

The coal at the Dean bank is about 9′ thick and quite a large country trade is done here. About 6′ of coal is taken out. The main gangway is driven about N 65°—67° W on butts and *drains south-east.* It will be carried through the point of the hill, when shipping facilities will be secured on the railroad. Some of the coal now dug is loaded on wagons and thence to cars at Linn station and carried to Upper Middletown.

Above Linn station on the creek, the *Redstone coal* is first exposed, succeeded by the Fishpot limestone near the bridge. Then some flaggy sandstone 25′ thick and finally the *Sewickley coal*, 2′ thick, in irregular waves, exposed in a long railroad cut about a mile below Parkhill's mill. This bed passes beneath water level about ½ mile from the mill, and just below the mill the Uniontown or upper division of the Great Limestone shows 20′ above the stream. Thus far the dip has been *south-east* from Dean's bank; but here the measures begin to *rise to the north-west*, marking the bottom of the eastern sub-division of the Lisbon basin. The Waynesburg limestone is exposed on the surface in the trough, and proceeding up stream, the Uniontown limestone again appears just above the mill and successively lower rocks come up to the line of Franklin township, where the lower division of the Great Limestone appears above water.

Detailed descriptions of the exposures of these higher measures, and the bottom coals of the Upper Barrens will be found in Report KK., p. 212 etc.

Perry township flanks Washington and Jefferson on the east, lying south of Jacobs creek and north of Franklin. The whole of this township comes within the *Lisbon synclinal*, the *Fayette axis* touching Jacobs creek about 3½ miles from the river and the river itself below the mouth of Virgin's run, passing south-west a little west of Flatwoods P. O. to the Redstone creek at Upper Middletown. This axis then practically marks the eastern township line, being fairly co-incident with Virgin's run. The section exposed extends from the *Waynesburg coal* down to the Mahoning sandstone.

At the mouth of Jacobs creek, the *Pittsburgh coal* lies pretty high in the hills, and as this is right on the edge of the eastern limit of the area of the Upper Productive measures, the coal is rising rapidly south-east towards the Fayette axis, and just catches in a small knob between Jacobs creek and the river. This is the *only* area of these higher measures east of the Youghiogheny. On the west side of the river, the outcrop extends rather south-west, and where the river bends sharply above Bannings station, the crop takes a nearly south course to Perryopolis. The first opening is *Larimer's country pit* at Bannings station on the west side of the river at 804′ A. T. This opening was abandoned. The bed is about 20′ above the P. McK. & Y. R. R. track. Another pit to the north shows the lower division 8′ 8″ thick, and the main clay 1′. The benches of the lower division are 74″, 3″, 12″ and 20″, the breast coal being parted by a thin slate band at about 15″ from the bottom.

On Browneller's run, which enters the river at Larimer's pit, a good section of the Upper Productive measures shows the *Redstone coal* about 50′ above the Pittsburgh; the Fishpot limestone 15′ higher and 10′ thick; the *Sewickley coal* 20′ higher and 105′ above the *Pittsburgh*, capped with the lower division of the Great Limestone 55′ thick.

On the opposite side of the river, at Whittsett station, so rapidly do these measures rise to the south-east, that not a vestige of these rocks are left on the hills there.

The *Morgantown sandstone*, 150′ below the coal, makes a fine bluff there, considerably above water level. Above it there is a yellow limestone and below it is the *Barton coal* *bed.* The *Crinoidal limestone* occurs still further south at about 80 feet beneath the *base* of the sandstone, and is 140′ above the track; and successively lower members of the Barren Measure group come up from the level of the Youghiogheny river in going south to Layton station and Virgin's run, where the anticlinal passes.

The *Rainbow Mine* (Whittsett & Co.) is opened further south at Whittsett Sta. on the same side of the river at 804′ A. T. In this mine the coal is taken out only to the bands and shows 5′ 3″ of breast, 3″ bearing-in, and 1′ of brick. The main clay is about 1′, as measured in the 4th room off the main entry, and 1′ of top coal.

The main entry starts in the hill on a course of about S. 35° W., and the water collecting in it is syphoned.

All rooms have been turned off towards the crop, none having been worked to the dip, which is here strongly north-west. The rooms are 21′ wide with 10′ of a rib between; all single entry. The breast coal makes slack for 6″ to 1′ *above* the bands and also for 6″ on top; the balance is excellent, clean, bright lump. They run out about 25 cars a day.

The crop keeps well back from river to the south of here, crosses the Perryopolis road about ¼ mile north-west of the town, and goes under water level on the head waters of Washington run, about ½ mile due west of the town.

Returning on the south side of the stream, it extends south along the west side of a south branch which it touches about 2 miles from Perryopolis near Kinnear & Co's. grist mill.

It is opened about ½ mile south-west from Perryopolis at *Rankins country pit* at 1000′ ± A. T. The dip here is quite severe, 1 in 16. Only the breast coal is mined 5½′ thick. The other benches show 3″, 11″ and 24″. The brick is good, but not mined.

About half a mile further up this run (Stickle hollow) is the *Frances pit*, on the east side of road at 1080′ A. T. This pit was pretty well filled with water; but the roof members show:

Sandstone,	4'
Shales,	2'
Coal,	0' 4"
Slate,	0' 2"
Coal, with thin slate bands,	0' 10"
Clay slate,	0' 3"
Coal, bony and impure,	1' 0"
Main clay slate,	0' 10"
Breast coal,	5' 4"+
Bottom not seen,	——

The *Lynch pit* is nearly opposite on the west side of road 1050' A. T. The roof division is here about 3' thick, and the lower division 7'+, of which about 5' 4" is breast coal. The main clay is thin.

E. Lynch's pit adjoins, opened on butts and at 1045' A. T. In neither case is the coal satisfactorily exposed.

Beyond the cross roads to the south, the *Pittsburgh coal* crosses the road at the smith's shop at about 1035' A. T. and soon passes under water level. The *Redstone coal* shows further along the road at 1080'.

The road rises over a divide to the head waters of Crabapple creek, to the south-east, and the coal is opened on the east crop at *Townsend's pit*, where it is considerably higher and shows roof division 2', main clay 8" and lower division 6' 8". The breast coal is 5' thick and bearing-in 3".

East from here to the river line and Virgin's run, the Barren Measures are everywhere the surface rocks, a small area of the Lower Productive measures being brought up under the arch of the Fayette axis at the mouth of Virgin's run, and extending half a mile down river.

Brownsville township lies immediately south of Jefferson, facing on the Monongahela river as far south as Dunlap's creek. But it is a small area, and can be conveniently considered *geologically* a part of and described with *Redstone township*. The latter is an important area, with Redstone creek for its northern boundary; Dunlap's creek for its western boundary while parts of other streams and township roads make up its dividing line from Menallen. Its shape therefore, is excessively irregular. In the combined extent of these two townships, the Upper Barren measures occupy by far the greatest portion of their area, with a small strip of the Upper Productive measures flanking the two bounding creeks, and a still more limited area of the Barren Measures along the river, in the neighborhood of Brownsville and at the mouths of the creeks.

The entire area lies in Redstone twp. within the eastern sub-division of the *Lisbon synclinal*, whose deepening trough holds the *Pittsburgh bed* far below the surface of the ground.

The axis line of this sub-basin enters on Redstone creek just below Parkhill's Mill, crossing the National Road near G. Calley's house, and Dunlaps creek near Mr. Hibbs house. The sub-axis passes through Brownsville twp. from the Dean mine on Redstone creek ; but it is obscure. The only openings along Redstone creek on the *Pittsburgh coal* are on the Jefferson Co. side, except the rear pit of the Umpire mine, which is but a little way below Deans and at 795′.

Umpire mine (C. L. Snowden & Co.) lies about 400 yards south of the P. V. & C. R. R. bridge crossing the river at the mouth of Redstone creek, and at 752′ A. T. It was entirely abandoned in Sept. 1885, and the following facts are abstracted from K^4 p. 12 :

The old main entry is driven against the butts, from the river to (Redstone) creek, a distance of 1,100 yards, and raises 15 feet. The new main entry is quite crooked, and driven about S. 20° E. and the mine is worked somewhat on the block system.

Butt entries are driven 180 yards apart, and the air-courses are driven single, 100 yards apart. The face entries dip in a southerly direction at the rate of 1½ inches per yard, and the coal rises up creek (towards the sub-axis) at the rate 5 feet in 200 yards.

Bearing-in is done 6″ above the bottom, giving about 7½ feet of mining coal. The section of the bed will average :

Main clay parting from 0′ to	2′	0″	
Breast *coal*,	5′	2″	7′ 10″
Bearing-in *coal* and bands,		2½″	
Brick *coal*,	1′	2″	
Slate parting,		½″	
Bottom *coal*,	1′	3″	

The *over-clay* is quite variable, and in a considerable portion of the mine is entirely absent. The total output here in 1885 reached 18,340 tons.

The roof division along the river varies from 1 to 5 inches and is all coal. The lower division frequently shows no partings, except occasionally one at about 10″ from the bottom.

The whole bed yields a marketable coal, for the most part free-burning and carrying a bench of good block coal near the middle.

The *Redstone coal* is exposed at the tunnel of the railroad, north along Redstone creek, only about 1 foot thick and 25 feet above the *Pittsburgh bed.*

A couple of abandoned openings in the large bed are seen further south, in the borough of Brownsville; and just across Dunlaps creek, in the borough of Bridgeport is the *Bridgeport Slope mine,* operated for local supply, where the coal is reached by a slope 100 yards long, and 33 feet deep, at about 750′ A. T. Right across the river here is the Knob mine in Washington Co., where the Pittsburgh coal is reached at 710′ A. T. showing the rapid north-west dip of the bed into the *western* sub-basin of the Lisbon trough.

The Bridgeport mine was idle in Sept. '85 and looked as if no coal had been run out of it for some time. The mine is drained through a drift cut to the river, the coal rising up Dunlaps creek, and sinking up river. The output here is abont 25,000 tons a year.

Along Dunlaps creek the *Pittsburgh bed* is available for half a mile above the township line of Redstone, and shows 7′ 8″ to 9′ thick. At Wood's bank the lower division is 7′ 6″ thick, and near the sub-axis. All the balance of these two townships is occupied by the different members of the Upper Barren measures, to 400 feet above the *Waynesburg coal bed.*

No commercial or economical importance is to be attached to these higher measures as yet, and no detailed description of them is called for here.

Franklin and *Menallen townships* occupy the strip of country between the Youghiogheny river and Dunlaps creek, lying east of Jefferson and Redstone and separated from each other by Redstone creek. They may be conveniently described together as the structural features of each are similar and coincident.

This *Fayette axis* extends from the river at or below Virgin's run south-west to Flatwoods; Redstone creek below Upper Middletown; the National Pike just west of the summit school house; the McClellandtown road at Watson's Knob and into German township.

It will be seen how seriously this axis is deflected in its course through this part of the field, which gradually becomes more nearly north and south.

This anticlinal divides these two townships into two basins—the *Lisbon* on the west and the *Blairsville* on the east. And so widespread has been the erosion of the measures along the arch of this crest that but limited areas of the *Pittsburgh coal* in each basin skirts along the two sides of both townships.

The terminal dip of the coal at the rim of each basin is very steep, consequently the erosion along the anticlinal has been vigorous, until assisted by the action of Redstone creek (which is still a powerful stream here) a considerable area of the Lower Productive measures has been exposed for several miles below Upper Middletown. Steep as the north-west dip, into the Lisbon basin is, the south-eastern slope of the axis is steeper still.

The *Pittsburgh coal*, on the edge of the Lisbon basin, enters from Perry township on the headwaters of Crab Apple creek.

On the road from the forks at Hazens to Franklin church the coal crops within a short distance of the church at 1170′ A. T. This is only a small outlying patch, cut off from the main area by a branch of Crab Apple creek.

The crop heads down the creek almost to the line of Jefferson and is opened by Messrs. Hazen and Burton, showing about

Roof coal and slate, ...	3′	0″
Main clay, ...	0′	8″
Lower division, ...	7′	0″

South of the Franklin church the crop keeps always west of Allen's run, getting further away from it as the Redstone creek is approached until turning squarely west it disappears on the creek below Smock's station and the old mill.

Ogilvie's pit is opened about half a mile from the church and about 250 yards from the road at 1190′ A. T. There is about 6½ feet of the lower division exposed at the pit mouth.

Piersal's pit was just being opened near by; same elevation. From here the crop swings around towards the Redstone Baptist church, crossing the road, east of the cemetery at 1100′ A. T. The coal is opened here at *Frazer* and *Murphy's pits.*

From the church, the road to Smock's station keeps just on top of the coal, in the overlying sandstone, crossing the bed near the railroad, where it is opened a couple of hundred yards below at *Boyd's mine* at 900′. The distance from the church is not much over a mile and the coal falls 200 feet.

Boyd mine (J. D. Boyd & Co.) is opened about midway between the station and the disappearance of the coal bed beneath Redstone creek, at 900′ A. T., and about 45′ above creek level. The pit is on the south or Redstone side of the creek, and a trestle spans the stream to the railroad tipple. The development is not a large one. The main entry goes in about on face S. 23½° W.

The entire lower division is mined here, the 3″ between the bands being thrown aside at the tipple.

The usual bed section shows:

Roof coal,		6″–8″
Main clay parting,	1′ to 0′	9″
Breast coal,	5′	4″
Bearing-in coal,		3″
Brick coal, Lower bottom coal,		3″+

The top coal forms the roof here, the main clay being too treacherous for safety in mining. The average run here is 7 or 8 cars of 20 tons each.

The dip is strongly north-west and continues so to and beyond the Jefferson line.

At the latter point, the Fishpot limestone is about at water level, 25′ thick and separated from the *Sewickley coal bed* by 25′ of shale. The Great limestone appears above the latter, its members considerably divided with sandstone beds, and finally the blossom of the *Waynesburg coal,* 200′+ above the *Sewickley.*

At Cook's mill, the *Pittsburgh bed* is 120′ beneath ground, only a half mile from where it rises to daylight below Smock's station.

The measures continue to rise rapidly above Smock's until the *Upper Freeport coal* (?) appears above water level at Wolf Run station, and the force of the Fayette anticlinal is sufficient to keep the Lower Productive measures in sight above the creek to and beyond Upper Middletown. If the coal at Wolf run can be identified as the coal at water level above Upper Middletown, it is probably the *Upper Freeport coal bed.* At Wolf run it is 885′ A. T. dipping north-west into the Lisbon synclinal; at Middletown it is 895′ A. T. dipping south-east into the Blairsville (Connellsville) basin.

The Freeport S. S.(?) shows in the railroad cuts below Upper Middletown, and the Fayette axis probably crosses here. The south-east dip on the east slope of the axis, taken in connection with the gradual rise of the creek in the same direction, has caused a much less extensive outcrop of these measures on that side.

In a flat below Upper Middletown, the coal has been opened at *Nichol's bank* on south side of creek at 906′ A. T. It is here 30′ or 40′ above the creek and dipping south-east. The coal is reported 3½′ thick, without parting. Of this amount 40″ shows at the pit mouth.

A small ravine to the west of this probably closely marks the anticlinal. Stewart's well was being drilled then (August 2, 1885,) and struck the Upper Freeport coal, at 7′ below the surface or 910′ A. T., with the Mahoning S. S. cropping in ledges in the ravine above the derrick.

No reliable records of this well could be obtained. It was then down 600′, but reports having struck a 5′± coal bed at 270′± below the surface. At 460′ a hard sandstone through which the drill had passed 145′ to slate. No reliance is to be placed upon this record.

Ascending the creek higher the section is repeated, though in reverse order, the *Pittsburgh coal* coming in again on the western rim of the Connellsville basin, and disappearing beneath water level beyond Vance's sta. in Union twp. A detached area of the *Pittsburgh coal* shows in the hill north of the station and west of Bute's run. The coal is high on the hill at *Vance's pits* at 1028′ A. T. and 1013 A. T.

Allen's pit, immediately on the opposite, on east side of creek, is 963′. The coal is opened in various country pits going up Bute's run; at Phillip's 1020 A. T.; Bitner's and Boyd & Cleaver's 1025′, and near water level at end of crop at *Long's pit*, 1020′.

The crop returns on itself nearly 2 miles, swings around the hill north-west, and then strikes north-east, up the east bank of Boland's run, 4 miles from Vance's Sta. to *J. C. Coon's pits*, near the summit of the road at 1270′. This shows the marked rise of the coal north-eastward, 240 feet in 4 miles, or 60′ per mile.

The Fayette anticlinal lies fully 2 miles west from this point, beyond Flatwood's.

Taking up the line of outcrop along the eastern edge of the Lisbon basin, south of Redstone creek, in Menallen, the *Pittsburgh coal* is found just above water level at the Jefferson line. In a hollow south of Smock's sta., a rear pit mouth of the Boyd mine discloses the coal; but the Upper Middletown road soon rises above the coal, which sweeps around the hill, along the creek bluff, gradually rising south-east and returning to the *Roderick pit*, on the south-east side of the hill at 1095′ A. T.

This overlooks Redstone creek, where the Upper Freeport coal is 20–40′ above water level. The breast coal is here nearly 7′ thick; bearing-in 3″; brick and lower bottom 1′+.

A small outlying patch of this coal shows on the very summit of the hill, all weathered, back of D. Hill's house at about the same elevation.

The crop then takes a north-west course for over half a mile to the head of the hollow; crosses the road between the two Hornbeck houses; and returns on itself to the *Hornbeck bank*, on the south side of road at 1065′ A. T.

It next extends up Campbell's hollow 400 yards, and is opened at both the Cowle and Campbell pits, close to water level, at 970′ A. T., showing an almost abnormal difference of elevation as compared with Hornbeck's. From here the crop assumes an almost due south course to the National pike, indented by every little stream tributary to Redstone creek.

Woodward's pit was the first seen, located in a deep ravine, about a mile north of Searights P. O. at 1070′ A. T. Returning from the ravine northwards, it next crosses the Searight and Upper Middletown road and is opened at *J. Veil's pit*, east of that road at 1120′ A. T.

This opening is just about ½ a mile due south-east from Woodward, along line of greatest dip, and on comparison of elevations, shows a rise of just 100′ per mile. The crop swings for nearly 2 miles south-east from here and approaches to within ¼ mile of the anticlinal, and is opened on the National Pike near the limits of the crop at 1190′ A. T.

The axis is just east of this, crossing the pike ¼ mile west of the brick school house, carrying the Connellsville sandstone on its crest. From the last mentioned pit it extends half a mile north-west, cut out along Salt Lick run and the pike, to *Woods pits*, at 1120′ A. T. The coal here is 11′ thick, of which 9′ is taken out; 6′ 6″ above the bands, with the blossom of the Redstone coal 25′ above it.

The coal extends a mile down Salt Lick run, in a south-east direction before passing beneath water level, and returns on itself ¾ miles to be opened at the *Jackson* and *McCrea banks*, in a branch hollow at 1125′ A. T. A branch of Dunlaps creek again cuts out the coal to the east, and isolates a considerable area between the pike and the road leading south-east from Woods to Dunlaps creek.

Graham's pit is an abandoned opening towards the extreme southern edge of this patch, along the road at 1140′.

Three quarters of a mile south of the Jackson and McCrea openings the crop touches a township road at Woodward's and turns at right angles west to *Supper's pit*, opened at roadside, near creek level, at 1050′ A. T. curving thence south and west to Dunlaps creek 1½ miles south-east of New Salem.

The outcrop here turns again at right angles toward New Salem, heading up a couple of short ravines, and passing beneath creek level about ⅛ mile east of New Salem, on the border line of German township.

All the area of Upper Productive Coal measures in the township lies west of the outcrop line thus traced, along the Redstone township side, and in the Lisbon basin, and *all* the members of this group dip north-west into that trough. At the New Salem cross-roads the *Pittsburgh coal* is about 300 feet beneath the surface, so rapid is this dip, and about ⅛ of a mile west of the village the blossom of the *Waynesburg coal* shows in the road.

On the National Road the *Washington coal bed* is exposed just beyond the western township road and at Searight the road passes just over the Uniontown limestone.

Luzerne township is the most western township of Fayette Co., lying in the great double bow of the Monongahela river between Bridgeport and the north line of German township, and with Redstone township and Dunlaps creek forming its eastern boundary. with the exception of a small strip of the Barren Measures on Dunlaps creek, and another along the river between Lock No. 5 and Millsboro', the *Pittsburgh coal bed* is buried beneath a thick covering of the Upper Productive and Upper Barren measures, which about equally form the surface rocks of the township up to above the *Washington coal.* The entire township lies wholly within the *Lisbon synclinal* both sub-divisions crossing through the township from north-east to south-west, and separated from each other by the sub-ordinate anticlinal, which has already been noted on Redstone and Dunlap's creeks and which meets the Monongahela river somewhere below the mouth of Muddy run. The western sub-basin, after leaving the county on the river below the Climax mine passes into Washington, and re-enters Fayette Co.

in the vicinity of Lock No. 5, and passes through Luzerne township a little west of the line of Rush run to the Monongahela again about a mile above Lock No. 6. In the absence of developments its course can not be more definitely located, and at best the flexure is probably a very gentle one.

The eastern sub-basin barely touches the eastern edge of the township, along Lilly's run and *may* lie wholly on the Redstone side of the creek.

The *Pittsburgh coal* sinks beneath water level just below the mouth of Dunlaps creek, the river flowing nearly on the line of strike for nearly 3 miles, and the measures sinking south-west naturally. At Lock No. 5, the bed is not over 15′ below the dam. But as soon as it bends to the north-west between Keeley and Rush runs, the coal bed begins to come up to the surface at 750 ± A. T., and is opened on the Washington side of the river at the Black Hawk mine at 762′ A. T. It keeps thence above water level to the mouth of Coal run, opposite Millsboro', and is opened opposite Fredericktown at the *Evans mine*, in a small way, at 768.′

The entire bed is here about 10′ thick, of which about 8′ represents the lower division.

A section of the Upper Productive measures at this point is given in Chapter IV.

In the trough of the sub-basin above Lock No. 6, the *Pittsburgh coal* can not be far from 640′ ± A. T., or 100′ beneath the river in Pool No. 6.

From this point the measures rise gently to the south-east for a mile or a mile and a quarter to the sub-anticlinal. But the total increase of elevation can not be great, for in about a mile on the east side of the axis, up the river, *Jacobs slope* reaches the Pittsburgh coal at nearly the same elevation 640′ A. T. This slope is not in operation now. It is 389′ in length, and reaches the coal in a perpendicular depth of 155 feet or 112 feet *below low water*. This slope is situated near the mouth of Wallace run.

It is said that a sump entry here, *driven down river*, dipped at the rate of one in ten, which would tend to place the sub-axis to the east of this point; but the relative elevation of the coal here and as estimated at a point 1½ miles above Lock No. 6, render the facts as stated fairly correct. The coal at Jacob's slope is 11′ thick.

Along Dunlap's creek, the *Pittsburgh bed* is available for nearly two miles from the river, up to Mr. I. Allen's property. Its characteristics here have already been described in connection with the geology of Brownsville and Redstone townships.

Along the whole river line, the *Waynesburg coal bed* is within easy reach on the hillside, and as the interval from it to the *Pittsburgh coal* is everywhere about 350 feet, from Brownsville to the State line, it forms a convenient guide to the structure of this region.

The two following sections show its usual character, No. 1 at Wood's bank, 1 mile south-west of Heistersburg, No. 2 pit on Telegraph road, ¾ miles from river.

		No. 1.	No. 2.
	1. Waynesburg SS,	20′	15′
Waynesburg coal KK. p. 237.	2. Clay shale, . . .	0′ 3″	8′ 0′
	3. *Coal*, ...	0′ 3″	1′ 0″
	4. Clay, ...	0′ 3″	1′ 0″ to 0′ 2″
	5. *Coal*, ...	2′ 0″	1′ 0″ to 0′ 7″
	6. Clay, ...	2″ to 10″	2′ 0″ to 0′ 10″
	7. *Coal*, ...	3′ to 4′	3′ 0″

The coal is rather inferior, though perhaps better here than elsewhere in the township. The coal at Wood's opening is dipping south-east.

The Great Limestone, further down the river is 70 feet thick. The *Redstone coal* is occasionally exposed, but as a worthless carbonaceous shale.

The *Waynesburg coal* passes beneath water level on Dunlap's creek, about a mile above Merrittstown, and at Mr. Struble's opening shows three benches of coal divided by clay bands, from 5′ 7″ to 7′ 4″ thick.

On the telegraph road again, about two miles from Merrittstown, the *Waynesburg coal* has been opened by Messrs. Knight and Garwood, but shows no special features at either place. The same bed is seen on the Frederick road, and has been mined on the Merrittstown and Heisterburg road. Near the latter place, the *Washington coal* is exposed in the road.

German township lies south of Luzerne and Redstone, along the Monongahela river to Cats run, and with Menallen and Georges on the east.

The eastern sub-division of the *Lisbon trough* passes through the north-west corner of the township, crossing Middle creek near the school-house and reaching the river below the mouth of Brown's run.

The *Pittsburgh coal* is deeply buried in its trough and is nowhere exposed along the river until within a short distance of the mouth of Cat's run.

The *Fayette anticlinal* occupies a similar position on the eastern side of the township, crossing near the cross roads at Newcomer's on the north-east and extending south-west to Nicholson township, nearly a mile east of the Lutheran church and parsonage. About the same section of rocks is exposed here as in Luzerne.

The eastern outcrop of the *Pittsburgh coal* along the rim of the Lisbon basin, is singularly diversified and irregular, and the western limit of the Connellsville—Blairsville basin is just as broken on the eastern side of the township. The two opposing outcrops nearly meet each other; but the position of the Fayette axis is marked by a shallow strip of the Barren Measures from ½ to 1 mile wide.

Along Cats run a good idea may be obtained of the strength of this axis from the lift in the measures it creates. At the river the *Pittsburgh coal* is about 775′–780′.

The creek flows a little south of west, and consequently is no measure of the dip of the coal. Still at the head of the outcrop on this stream, at *Diffenbaughs*, about 3 miles air line from the river, the coal is opened at 1054′ A. T. At the mouth of the run, both the *Pittsburgh* and *Sewickley* beds show on the Mr. Poundstone's property about 100′ apart, and the latter is full 5′ thick.

At the distillery further up the run, the *Pittsburgh* shows at 870′ A. T.

Carbonaceous shale,	8		
Coal,		1″ to 2″	
Sandy shale,	8′		
Pittsburgh coal bed,			
Roof division,	5′ 5″		13′ 3″
Main clay parting,	10″		
Lower division,	7′ 0″		

The roof division shows two benches of coal, separated by 15″ clay; the upper bench shows clay and coal 3′ 6″ thick.

The Great Limestone occurs 145′ higher and extends north to Masontown.

Several other openings show along Cats run; at *Johnson's* 990′ A. T.; at the *Menonite* church 1010′ and finally *Diffenbaugh's* 1054′ A. T. Although the coal takes cover at this point, it soon appears again on the edge of the basin on the township line south of the Lutheran church. To the north of this place, it is opened on the public road at 1170′ A. T. and then swings south again to the head of a small branch of Brown's run at 1120′ A. T. just a little west of the church. Here the crop returns north around Pisgah summit (1320′ A. T.) and goes under the South branch of Brown's run just above the school house.

Along the road up Browns run from here all the hills for several miles are too low to catch the *Pittsburgh bed* ; but close to the Georges township line, this bed, now dipping south-east into the Connellsville basin, crops at 1172′ A. T. and shows roof division 3′ 4″ ; main clay 4″; lower division 9′ 0″. On the North fork of Brown's run, the coal crops nearly to the main stream at 956′ A. T.

To the north-east, up stream, it is opened at *I. P. Kendall's* at 970′± A. T. showing 12′ 7″ thick, of which 9′ is the lower division. This coal has yielded a good coke, suitable for foundry purposes. It next shows at *E. Parshall's* at 1018′ A. T. and finally at its eastern outcrop on the south side of the stream at 1160′ A. T. An isolated area occurs still further east, but on the west side of the anticlinal, high in the hill above Mack's mill at 1230′ A. T.

Openings here belonging to Messrs. Mack and Newcomer show: Roof division 5′ 10″; lower division 8′ 7″, with the main clay parting varying from 0″ to 10″.

North of the stream, the outcrop heads up the several branches of the creek, with similar characteristics, crossing the Uniontown and McClellandtown road about 1¾ miles east of the latter place at 1200′ A. T.

Another outlying area of coal is cut off from the main body here, south of the road, and between two small branches of Brown's run at higher elevations, and the eastern extremity of the basin is seen a mile further east along the road, close to the anticlinal, where a small area of the *Pittsburgh bed* occurs with very little cover.

Foucher's pit is right along side of the road here at 1250′ A. T. About 70″ of coal is mined, with 15″ of coal above the pit pillars to the main clay 1′ thick, and coal untouched in bottom. This road is on the dividing ridge between the waters of Brown and Dunlaps creeks, and to the north of it, the crop skirts around the various branches of the latter, until passing beneath water level at *C. Antrim's pit* at 1005′ A. T., dipping north-west, and about 200 yards east of the New Salem road.

On Dunlap's creek, the coal similarly disappears about a mile east of New Salem, opened at *Hackney's pit* at 1025′ A. T. The axis is a little over a mile east of here, the intervening space being occupied by the Barren Measures.

The lower division of the bed through here measures about 8′ thick. The *Sewickley*, *Waynesburg* and *Washington coals* are opened at several places west of the Pittsburgh coal outcrop to the river; but they need not be discussed in detail here, having been fully described and located in Report KK.

Nicholson township lies south of German, and extends along the Monongahela river from Cats run to George's creek. Georges twp. lies east and Spring Hill south of it.

The *Fayette antictinal* enters very near its north-eastern corner, and keeps a practically straight S. S. W. course to Georges creek about midway between Hunter's mill and War Branch run. In its course through this township, the Barren Measures everywhere occupy its arch except in the centre, where the Pittsburgh coal extends over the crest; while the township, as a whole, is *geologically* characterized by the increasing area of those measures and the entire absence of any rocks belonging to the Upper Barren measures, as compared with townships lying to the north and already described. These changes are brought about solely by its geological position and the structural features governing the district.

The *Lisbon synclinal* trough lines lie wholly outside and to the north-west of this township, having reached the river to the north and passed on into Greene county.

The increasing strength of the Fayette axis as it passes from Menallen through German has, in a measure, ceased here; for in a section along Jacobs creek from the river for three miles up stream to the axis, the *Pittsburgh coal* rises only 320′ or about 100 feet per mile. This rise is severe of course; but not so abrupt as it is further north.

A considerable portion of the eastern side of the township is occupied by the *Pittsburgh coal* belonging to the Blairsville–Connellsville basin outcropping along branches of Crozier's and York runs. West of the axis all the measures exposed lie in the eastern part of the Lisbon basin.

The outcrop of the *Pittsburgh coal* is deeply cut out along Cats run, Jacobs creek and Georges creek, which, with their numerous tributaries, have serrated the edge of the Upper Productive measures into two or three distinct areas. The section of rocks exposed extends from 350′ below to 200′ above the Pittsburgh coal.

The *Pittsburgh coal* is everywhere accessible, and is largely eroded from the crest and sides of the anticlinal along Georges creek.

The *Redstone* and *Sewickley* beds are likewise largely present and are of mining thickness here, 4 and 5 feet thick.

Along Cats run, it has already been stated that the *Pittsburgh coal* extends up to Diffenbaugh's, 3 miles from the river.

On the Nicholson side, it is opened on the first south branch at *E. Walter's pit* 850′ A. T.; in the second ravine at *Eph. Walter's* pit at 890′ A. T.; in the third at *Jos. Longenecker's pits* at 1062′ and 1070′ A. T.; next at *F. Kefover's pit* 1071′ A. T. and finally Diffenbaughs. The bed section is nearly similar at all these openings and varies little from the following :

Roof division,	3′ 6″ to 4′ 0″
Main clay,	10″ to 2′ 0′
Lower division,	8′ 2″ to 9′+

At 4′ and 10′ below the coal here there are two beds of iron ore 3′ and 2′ 6″ thick, which were formerly stripped, roasted and boated to Wheeling. They are not worked at present.

Along the river south, the *Pittsburgh coal* was once actively worked at the *Cats run mine* (Ewing, Kendall & Co.) where an old plant of 60 ovens now stands. It is now entirely abandoned ; elevation 812′ A. T. The *Sewickley coal* 4′ thick, is nearly 80′ higher at the mouth of Cats run. A second opening on the Ewing, Kendall & Co. property, about ½ mile south of the mine, is opened at 842′ A. T., and just across a small ravine here is *Parshalls pit* at same elevation.

The coal seen all seems rather soft and the main clay parting is thick. These openings are about 200 yards below dam No. 7, at Jacobs creek. Along Jacobs creek for some distance, the coal keeps high in the hills, owing to the erosion of the stream.

The Connellsville sandstone shows at creek level at the forks of the stream about 1¼ miles from the river and on the road north to the German Baptist church, the Pittsburgh coal is opened 100′ above the stream, by barometer, and at 1000′ A. T.

The coal shows an excellent character here, of which about 6′ are mined, breaking out in beautiful blocks, like the coal of the lower river country. The roof coal is 2′ thick, with shale and slate roof. The *Sewickley coal* shows at turn of road below Fost's house at 1085′ and the Fishpot limestone beneath it.

The Great Limestone crowns the summit, extending for some distance north and south along the road past the church at 1170′ A. T., on the road leading almost directly from the church to Jacobs creek, the *Pittsburgh* (?) *coal* shows at Cover's lane at 1075′ A. T., and the Little Pittsburgh coal 35′ beneath it.

Still lower the Connellsville sandstone shows at creek level, on top of which occurs 20″ of shaley coal, capped with 18″ of bastard limestone, and all overlaid by 6′ of sandy shale. Jacobs creek cuts off this northern area entirely from that to the south as shown on the map.

Between the two main branches of the creek, there is quite a large, but isolated area of the coal; and another outlying patch near Mr. Jos. Bare's between the public road and the axis. Between Jacobs creek and Georges creek the map will show a third extensive area of this coal, opened only to a very limited extent, and lying pretty high.

On the river bluff two old pits show it at 930′ and 983′ A. T., while on the road from New Geneva to Smithfield, the coal at *A. Crow's pit* shows, just at the forks at 1060′.

From here north-east for nearly three miles the ridge road keeps above the coal which crops again just before the Jacobs creek road is reached, at the Presbyterian church, and is opened at *Anderson's pit* (abandoned) at 1160′ A. T. within half a mile of the axis. Tributaries of York run and Jacobs creek oppose each other at this summit and cut out the coal. Just across the depression, the coal has been opened at *Monaghan's pit* at 1165′ A. T., where the lower division is 8′ thick. This opening is in a separate area of coal which arches over the Fayette axis and into the Blairsville basin. On either side of the ridge road just mentioned, the *Pittsburgh coal* is available on any one of the several tributaries of either Georges or Jacobs creek, and the elevations of the bed at different points are shown on the map. At none of these openings was the bed fully exposed and rarely more than 6′ of coal was mined.

At New Geneva the *Pittsburgh coal* is almost 300′ above the river level, and consequently a good section of that much of the Barren Measures occurs here.

This section need hardly be repeated here, for it is figured and minutely described by Prof. Stevenson in Report KK.,

p. 250. It is mainly interesting from the several beds of iron ore which occur here, and formerly well opened up. These are the same in part, as those outcropping on Jacobs creek, Cats run and along the river, and are also identical with the Fairchance furnace ores in Georges township.

Spring Hill township is the most southern "river" township of the county, lying along the Monongahela from Georges creek to the West Virginia line, with Nicholson north and Georges east from it.

Cheat river flows through its south-west corner to Point Marion. The Upper Productive measures occupy the high land between Cheat river and Georges creek, extending west to the Monongahela ; the Barren Measures flank the rivers and streams of the township, *below* the *Pittsburgh coal bed*, while the Lower Productive and Sub-carboniferous measures occupy a portion of the extreme south-east corner, where they are elevated by the *Chestnut Hill axis.*

The *Fayette anticlinal* enters the township on Georges creek, near Crow's mill ; passes the ridge near the Methodist church 1½+ miles west of Morris cross roads, and crosses the Cheat river a short distance above its mouth, on to Monongahela Co. of W. Virginia.

The *Pittsburgh coal* area is divided into two main parts just west of Morris cross roads, being cut out by Bower's run branch of Cheat river and a small branch of George's creek.

On the road from New Geneva to Morris cross roads, the crop is first met about a mile from the river, just west of the school house at 1090′. Above this the *Sewickley* ("5 foot bed") crops on both sides of the road about 90′ higher.

Grime's pit in the lower bed is opened just below the road at the head of next ravine at 1130′ A. T. and shows a sandstone roof ; 2′ of roof coal ; 8″ main clay and 6′ 6″ of lower division exposed. Between these two beds, the *Redstone* 3′ thick, outcrops in the road.

Sackett's pit, in the point of hill east of Grimes, exposes the Pittsburgh coal at 1150′ A. T., and at the cross-roads above this, to Point Marion and Geneva, the *Redstone* again shows at 1180′.

On the next summit, the *Sewickley* crops without cover at 1225′, and 200 yards further on towards Cheat river and beyond the smith's shop the *Pittsburgh bed* is opened at *T. J. Burchinal's pit* at 1160′ A. T. The bed is 11′ thick here, of which 8½′ is lower division coal.

On the road leading north-west from Methodist church, the bed is opened on both sides of the road by A. J. Gans at 1165′ A. T. The coal mined is 7½ feet thick, with bottom left in.

On the south side of the main road, south of the church and school house, the bed is opened by A. Crow at 1170′ A. T. Both these last mentioned openings are close to or immediately upon the crest of the Fayette axis.

All the coal from here east lies in the Blairsville basin and dips south-east; and there is no apparent difference whatever in the character of the coal mined in either basin.

The outline of the crop becomes excessively irregular to the east of the Fayette axis, and it is shown with a fair degree of accuracy on the map. The first openings are seen just beyond M. Crow's house, on both sides of the road, below school house at 1165′.

East of this, on the main road, is *A. Scott's opening* at 1150′ A. T., the bed now beginning to dip to the east. The coal mined here measures about 6′ thick, with nearly 4′ of coal and clay slate to the roof.

Beyond this the crop is cut out, and is seen again on the road just west of Morris cross roads at *Jno. Lyon's pit* 1125′ A. T. where only about 5′ of the entire bed is mined. Morris cross roads, at the hotel, is at 1150′ A. T.

T. Scott's bank is just north-west of the hotel 200 yards at 1105′ A. T., where 6′ of coal is mined, furnishing about 3000 bushels yearly. South along the road from here to Cheat river, the *Pittsburgh* coal extends to the river bluff, and is opened on the road about 2 miles from Morris cross roads at *Hill's pit* 1050′ A. T. The road shows the *Sewickley coal* in several places.

To the east of the cross roads, the road keeps above the coal for nearly a mile, until exposed at the head of a ravine at

T. Lyon's farm at 1045′ A. T. Crossing the ravine the road again gets above the coal until crossing its eastern outcrop along Grassy run.

To the north the coal is opened at *Fast's pit* at 1100′ A. T., and crossing summit to west of this, at *Stewart's pit* 1110′ A. T. and finally on the road to Hunter's mill, near *J. Hard's place*, at 1120′ A. T. Its character varies but little throughout this distance.

CHAPTER X.

PART I.—*General Mining Methods of the Pittsburgh Coal Region.*

By **SELWYN TAYLOR**, *Pittsburgh, Pa.*

1. Prospecting.

In opening mines in this district, complete surveys are usually made of the tract of coal to be mined, locating all outcropping, and showing the difference of level between all points at which the coal is to be found. With this data it is then determined in what place to open the mine, and in what direction to drive the main gangways or entries. If possible, the mouth of the drift is so located that the main entries will be driven on the raise of the coal, thus making the mines self-draining; this however is not always, or even often, possible, as the coal very frequently dips directly away from the railroad or river, as near which as possible the mine must be opened.

The working of the coal to the dip is not usually a matter of very great disadvantage, as the dip is so slight that it does not materially increase the hauling expenses, and so many openings for drainage may be easily had to the outcrop.

If possible. all entries are driven on the "butt" (N. 65° W. or S. 65° E.), or "face" (N. 25° E. or S. 25° W.) cleavage. The main entries are generally driven as near the "face" cleavage as possible, while the entries from which the rooms, or working places are turned, are always driven on the "butt" cleavage.

Almost all the mines in this district are opened by drifts; the main entries are usually driven double, and sometimes treble; that is: two or three entries are driven

Fig. 1

MAIN ENTRIES & CROSS OVERS.

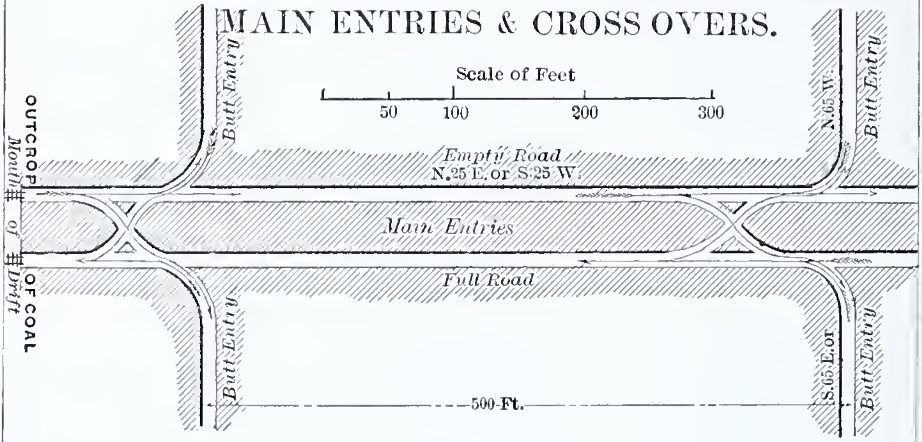
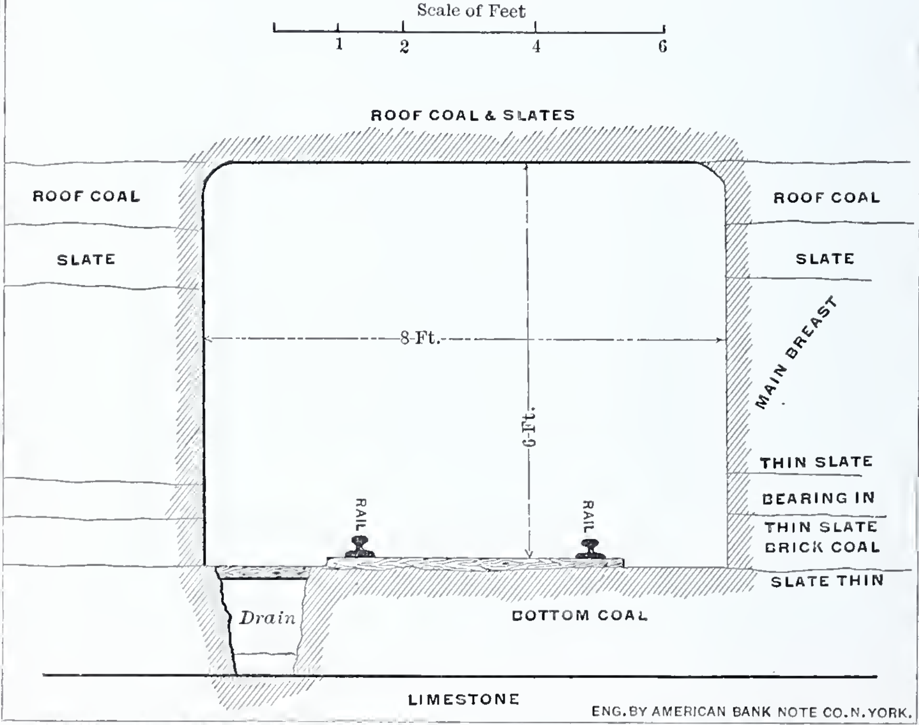


Fig. 2.

MAIN ENTRY, VERTICAL SECTION.



ENG. BY AMERICAN BANK NOTE CO. N. YORK.

parallel with each other; a wall of coal twenty five to forty five feet wide, called entry pillar, is left between these parallel entries; also, on either side of these entries, pillars, of from eighteen to thirty feet in thickness, are left for protection of travelling ways.

The main entries are usually driven from eight to nine feet in width, except at the front, that is: the end of the engine plane, where the entry used is made from twelve to fifteen feet wide, in order that two tracks may be laid in it.

"Break throughs" are made every thirty yards between these parallel entries, (see fig. 1, page 374.) At the mouth of the drift the entries are well timbered, as the shallow nature of the hill at the out-crop would cause them to continually fall in.

Enough roof coal is generally taken down on the main entries to make them five and a half or six feet in the clear.

Fig. 2, page 374, shows a vertical section of the usual main entry. The track on the main entry, as it is to be of a more permanent character than that on other entries, is usually laid with heavier iron, being from twenty to thirty pound per yard of steel or iron T rail.

In driving the entries a wooden rail is first laid; this is replaced, from time to time, by permanent road-rail. Iron lasts well in the mines, as the roads are generally kept dry, and the rolling stock used is light. Ties are placed about every two feet and are made of three by four inch timber.

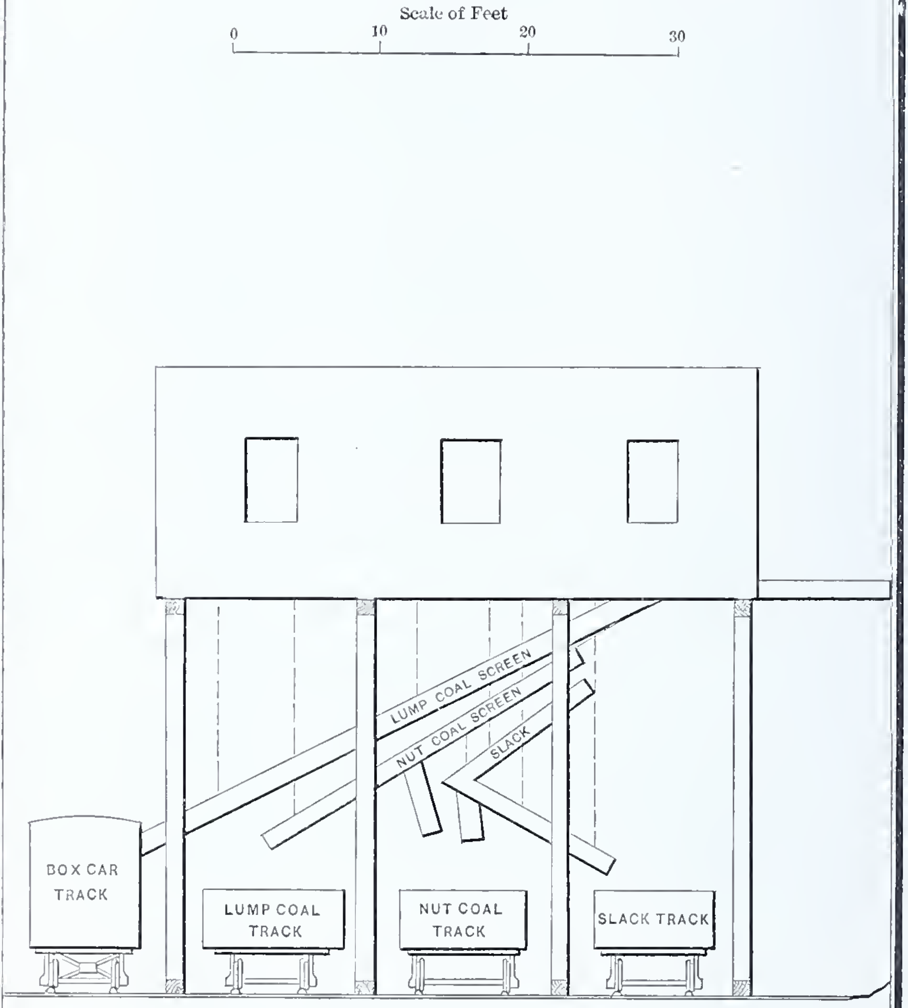
Surface Plant.

At some of the mines in this district, the out-crop of the coal is at the proper elevation for tippling and consequently the only building required is the tipple proper and possibly some short trestle-work.

Tipples are of two kinds; (a) those used for unloading and screening the coal into railroad cars, and (b) those used for loading into boats and barges on the river.

The Railroad tipple is much the simpler of the two; consisting of a frame house forty to sixty feet long, fifteen feet

RAILROAD TIPPLE



Eng. by American Bank Note Co, New York.

high, and from eighteen to thirty feet wide. This structure is set upon four or five plain timber bents. The floor of the tipple is generally at an elevation of twenty-seven feet above the top of the track rails beneath. The bents are set about twelve and a half feet apart, thus leaving room for a passage-way between the bent and the car being loaded.

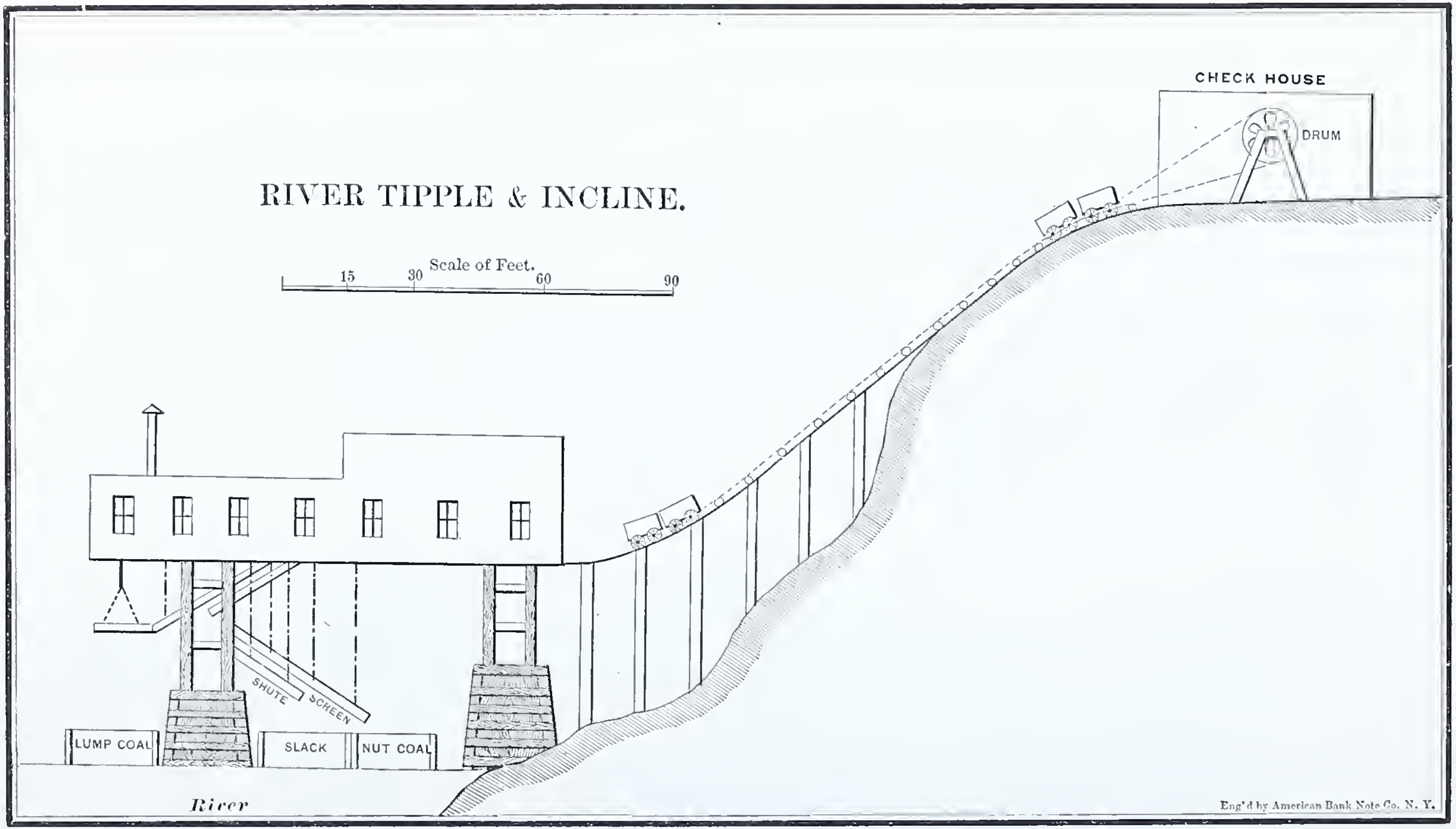
There are usually four tracks for cars under a tipple. The first one is laid just outside the end of the tipple and is used for the loading of box cars; the next track is for loading lump coal, the third one for nut coal and the fourth for slack (see page 376.

The two tracks from the incline or pit mouth merge on the tipple and end on the platform, balanced on a single shaft. This platform is so adjusted that with the weight of a wagon of coal, it tips forward to an angle of about thirty degrees; and when the end-gate of the wagon is open, the coal runs into the lump coal screen.

This screen consists of a longitudinal set of bars, one and a half inches apart, thus allowing all coal smaller than 1½ inches to pass through the bars. All coal larger than this is called lump coal and passes on over the bars, into a sheet iron pan, in which it is weighed and then dropped into the cars. The coal that passes through the 1½ inch screen drops to another screen, set directly under the first one, the bars of which are ¾ of an inch apart. All coal passing over the ¾ inch screen is called nut coal and passes directly from the screen into the car on the nut coal track. All coal passing through the ¾ inch screen is called slack and passes directly from a shute into which it is dropped to the car on the slack track. These screens are so arranged that the different sized coals may be loaded together, or any two of them loaded together on any one of the four tracks.

When lump coal, nut coal and slack are loaded together, it is called "run of mine." Lump and nut together make "three quarter" coal. Some of the tipples are built with two sets of screens and tipping platforms, each loading on the same cars.

The usual capacity of a railroad tipple with one set of screens allows one car of coal to tip per minute, loading from



RIVER TIPPLE & INCLINE.

Eng'd by American Bank Note Co. N. Y.

15 to 18 thousand bushels of screened coal per day, three to four thousand bushels of nut, and three to four thousand bushels of slack.

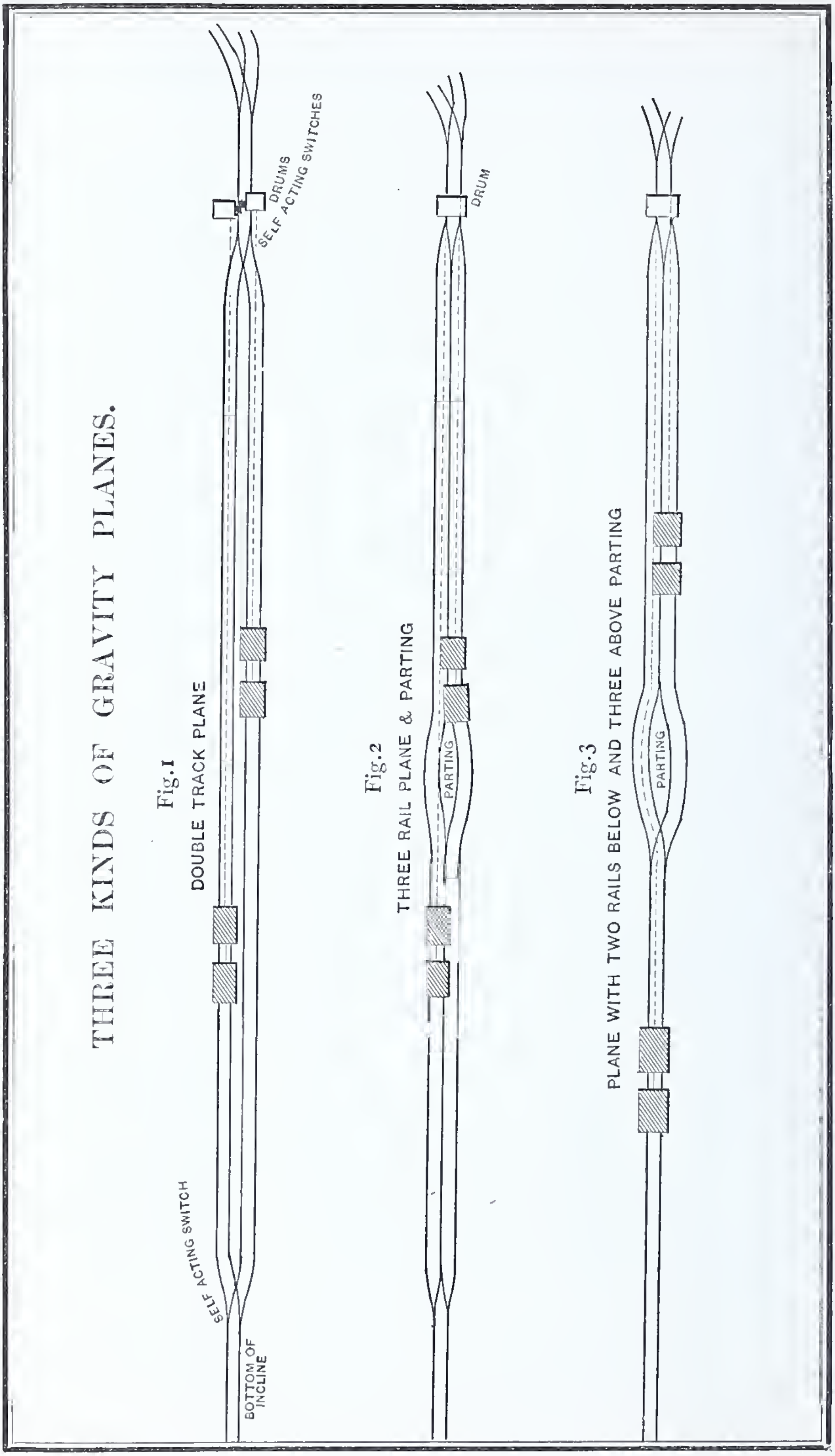
On the railroad tipple there are usually required but two men to operate; one to uncouple and move the wagons on to the tipping platform and then start them back towards the empty road; the other man to weigh the coal, dropping it from the pan by means of a lever, into the car beneath. One or two men are required to trim the cars and move them under the shutes as they are being loaded. If, however, box cars are being loaded, several more men are required to move the coal back from the door of the car.

The two tracks on the tipple are so arranged that the one on which the loaded wagons are standing, has a grade of four to eight inches per hundred feet, toward the tipping platform. The track for the empty cars has a grade of six to ten inches per hundred feet away from the tipping platform.

River tipples (see page 378) are operated much the same as the railroad tipple. The tipple building however, is usually set on two abutments or piers, one of which is set in the river. The floor of the river tipple is placed from 40 to 50 feet above low water mark; this must be done in order to allow the loading of coal at the increased stages of water. The only difference in the internal arrangement of the river tipple is, that the weight-pan is not fixed while that on the railroad tipple is.

The weight-pan on the river tipple is suspended by chains, from either side of the pan to a drum in the tipple. The pan is held in position, when empty, under the lump coal, by means of a counter weight suspended from the drum. When the coal passes into the weigh pan, the increased weight of the pan causes it to drop whatever distance the weigh-master allows, he controlling the drum by means of a brake.

On the river tipple is usually placed either a small stationary engine or hand windlass for drawing the empty boats and barges into position, under the tipple.



THREE KINDS OF GRAVITY PLANES.

Fig. 1 DOUBLE TRACK PLANE

Fig. 2 THREE RAIL PLANE & PARTING

Fig. 3 PLANE WITH TWO RAILS BELOW AND THREE ABOVE PARTING

For operating a river tipple, three or four men are required in the tipple proper, and several men on the boats or barges, to trim the coal.

The ordinary railroal tipple can be built for $2,000 to $4,000, while the river tipple costs from $4,000 to $10,000.

Inclined Planes.

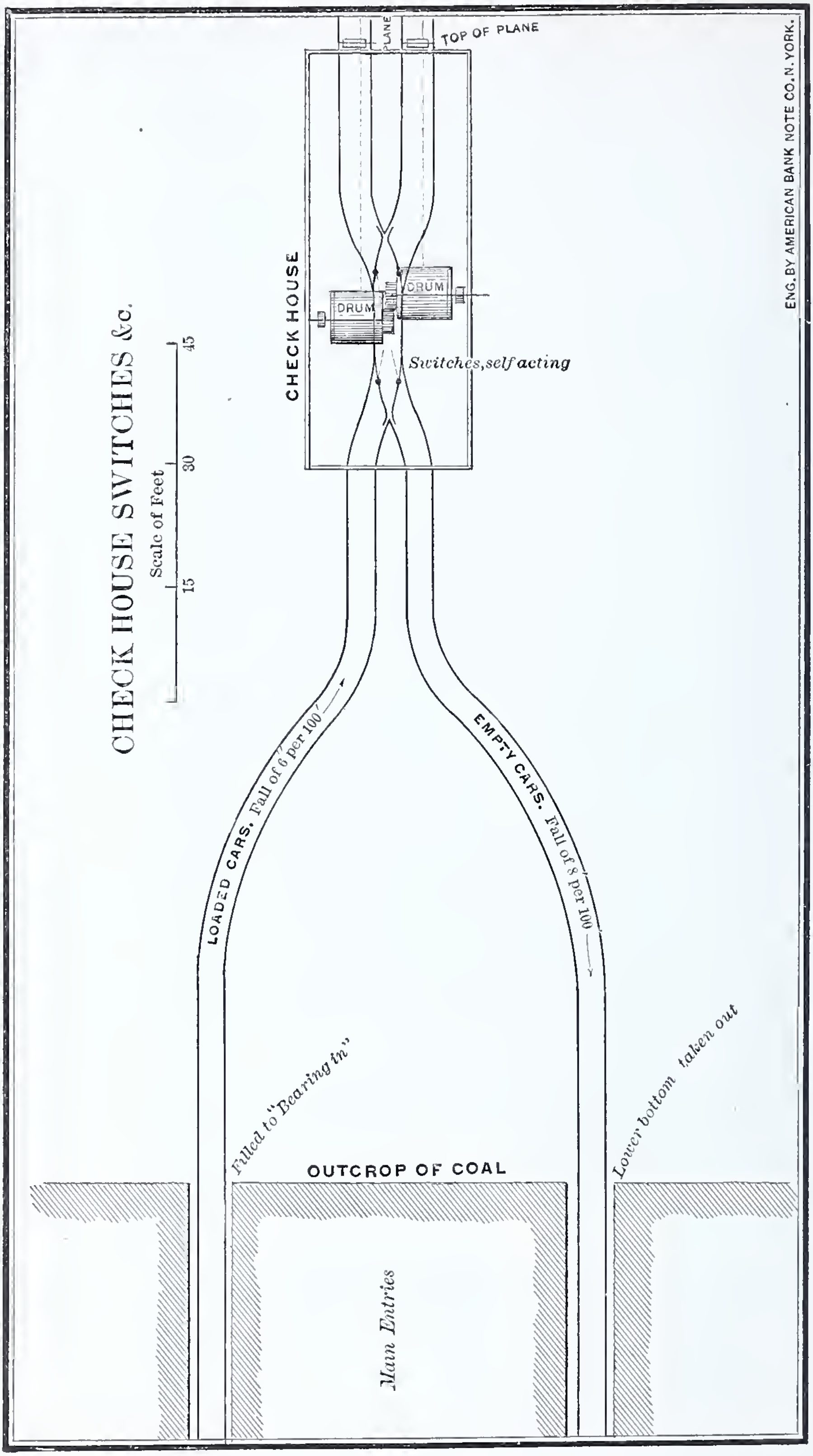
The inclined planes in use in this coal field are built to convey the coal from the mines when they are higher than the point at which the coal is to be loaded on the river or railroad, and are self-acting in character; that is, the weight of the loaded wagon traveling down the plane is sufficient to raise the weight of the empty wagons, by means of wire ropes attached to drums at the head of the incline. These inclines vary from 200 to 2,000 feet in length. The building in which the drums are located, at the top of the incline, is called the *check house.*

Inclined planes are of several different patterns. The best (Fig. 1, page 380) is that of a regular double track plane, merging into one track, both top and bottom. There are no switches or cross-overs required on this plane, and consequently it is by far the most safe.

Many of the inclines however, are built with three rails and a "parting" of four rails half way along the plane, for the loaded and empty cars to pass. Planes built on this plan are somewhat cheaper than that of the double track plane (see Fig. 2 page 380). Another plan is that of three rails from the top of incline to the parting, and but two from there to the bottom.

On this plan a self acting switch is required at the lower end of the parting (see Fig. 3 page 380).

The drums at the head of the incline vary from 5 to 15 feet in diameter, and are constructed of wood. The loaded cars coming from the mines are allowed to run down to a point directly in front of the drum, but are kept from going over the "knuckle" of the incline by means of a spring-bar held across one rail of the track. When the rope is attached to the car, or cars, this bar is drawn back, and the cars allowed to pass over the "knuckle."


CHECK HOUSE SWITCHES &c.

ENG. BY AMERICAN BANK NOTE CO. N. YORK.

The axis of the drum is horizontal. In cases where a single drum is used, two wire ropes are fastened to the circumference of the drum; one leading from under and one from over the drum, so that one rope must unwind while the other winds. The best plan, however, consists of two drums on different shafts, one back of the other, so that, by means of cog-wheel gearing, they are made to revolve in opposite directions. In this plan both ropes lead from the under side of the drum, thus avoiding any danger of the cars being lifted from the track by the height of the rope.

The speed of the cars on the plane is controlled by means of a break consisting of a band of iron on the circumference of each drum, which is drawn taut by means of a lever in the hands of the checkman.

Three men are usually required to operate an inclined plane: the checkman and an assistant, who couples, uncouples and shoves the cars at the head of the incline, and another man at the bottom of the incline, to shift, couple and uncouple the cars.

Check-house Switches.

The plate opposite represents the usual form for tracks and switches between the pit mouth and the check house. These switches are sometimes made self-acting by means of springs. This is the best plan where a fixed wheel on a wagon is used, or where the gauge of the wagons is perfectly true; but where the loose wheels are used and the gauges on the wagons are slightly different, or the wheels have much play, it is best to have a switch turned by hand rather than by the spring.

Nearly all planes have some arrangement by which if any accident occurs, such as the breaking of the rope or a coupling, the cars may be thrown off the track or stopped before reaching the bottom. Such arrangements consist of either a switch to turn the cars off the incline, or to move or drop a heavy timber called a "deadfall," across the track. Both of these arrangements are operated by a light wire line from them to the checkhouse.

The number of rollers required on an incline varies according to the grade of the plane, more rollers being required on a plane with easy grades. The rollers are placed at from 20 to 40 feet apart. Planes vary in angle of inclination from 5 to 45 degrees; many of them are concave in shape, being steeper at the tops than at the bottom.

Where the contour of the ground is an even one, the plane is simply a track laid on the ground. On most of the planes, however, the larger portion of them are built on trestle-work. T iron laid on cross ties is the usual manner of laying a track. Where, however, the incline is a steep one, flat iron, bolted to longitudinal timbers is used.

Nearly all the ropes used on planes are steel or iron wire ropes, though heavy hemp rope is occasionally used. The diameter of the ropes vary from half an inch to an inch and a half. Wire ropes are generally made of six wire strands, laid around a hemp or wire centre. Each wire strand is composed of seven or nineteen wires; any other number does not make a compact strand and therefore is not applicable. A wire rope lasts from one to five years.

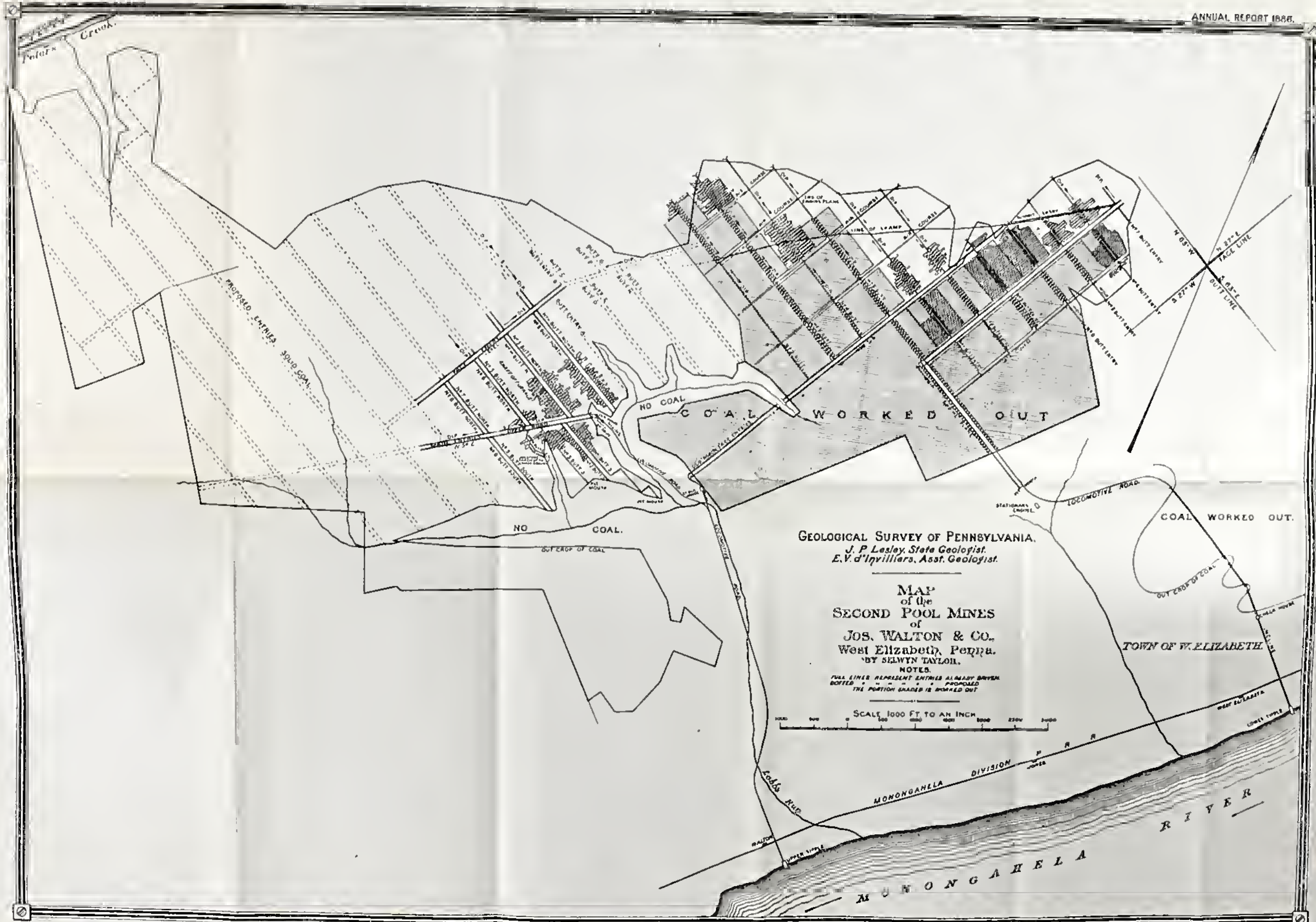
In opening a mine, distance is generally left between the check house and pit mouth, if possible, to allow for the placing of stationary engines and track enough to hold forty to 60 wagons.

The tracks are usually placed with such grades that the loaded cars will themselves run to the check house, and the empty ones from the check house back to the pit mouth.

The blacksmith shop is usually located at the pitmouth, one blacksmith and helper being all that is required to make repairs about the mines, and sharpen the miners' tools.

Entries.

There are two systems of entries in use in the Pittsburgh district mines; the first, which is the older system, is that of driving the butt entries one hundred and sixty yards apart, the usual distance, and face entries or air courses between the butt entries the same distance apart from each



GEOLOGICAL SURVEY OF PENNSYLVANIA.
J. P. Lesley, State Geologist.
E. V. d'Invilliers, Asst. Geologist.

MAP
of the
SECOND POOL MINES
of
JOS. WALTON & CO.,
West Elizabeth, Penna.
BY SELWYN TAYLOR.

NOTES.
FULL LINES REPRESENT ENTRIES ALREADY DRIVEN
DOTTED " " " " PROPOSED
THE PORTION SHADED IS WORKED OUT

SCALE 1000 FT. TO AN INCH

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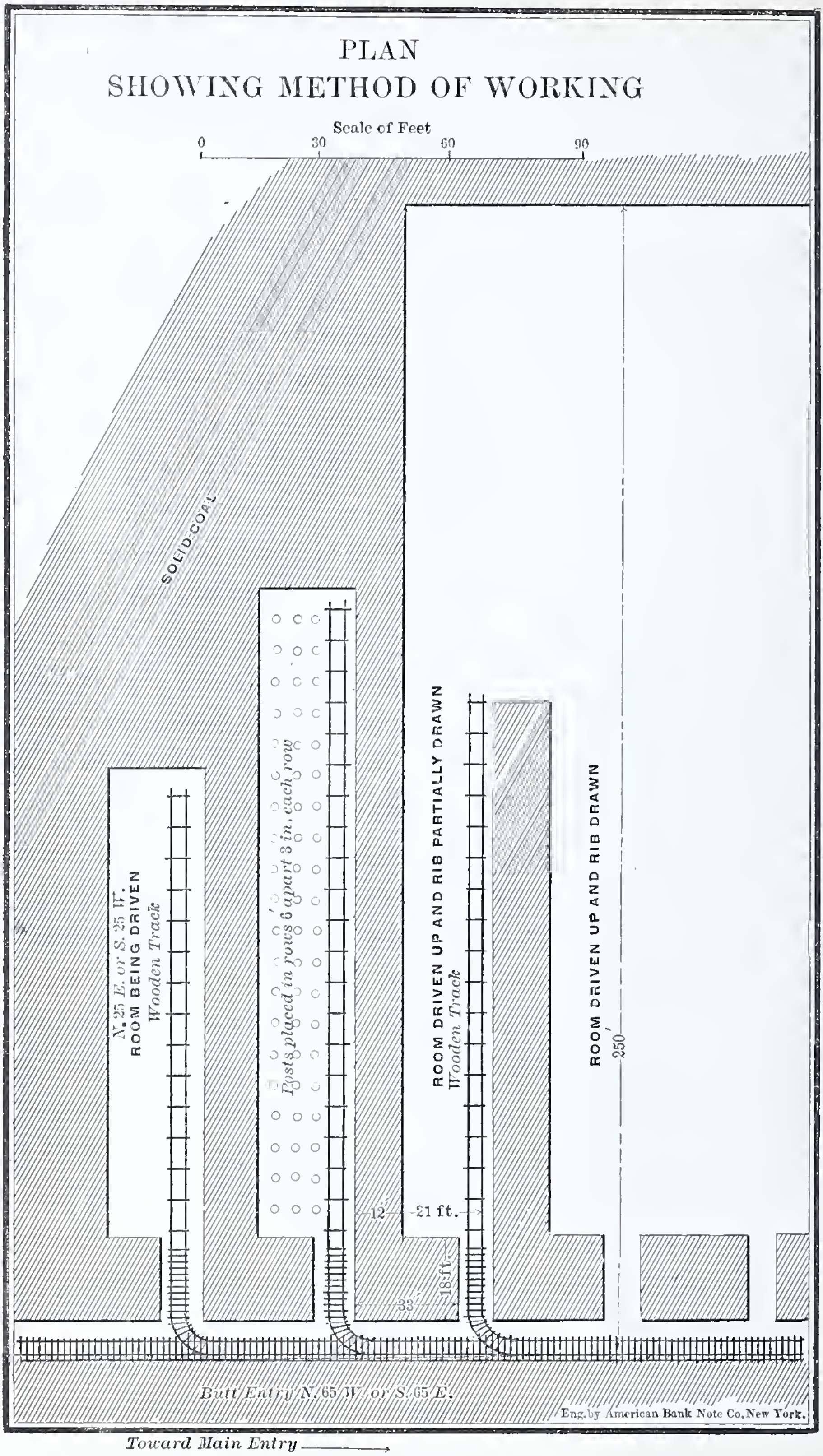
other, thus laying off the whole mine into blocks one hundred and sixty-five yards square. This is styled the single entry system.

All the mines now being opened are developed on the double entry system. Under this plan no air courses are driven, two butt entries instead of one being driven parallel with each other, 30 to 40 feet apart, leaving a solid pillar of coal between them, and turning rooms off on but one side of the entry. The same amount of entry driving is required under both of these methods, while 25 per cent. less entry stumps are required under the double entry system. Much better ventilation is acquired under the double entry system as the air can be kept constantly circulating to the heads of the entries by means of "break-throughs" between the two entries. Under the double entry system, it is possible to take out all the entry stumps or pillars, while from 25 to 50 per cent. of the entry stumps are lost under the single entry system.

The accompanying plan of Jos. Walton & Co.'s mine shows both methods in use, that of the lower road showing the single entry system with air courses, while that of the upper road shows the double entry system. Entry driving costs at present rate of mining (71 cts per ton) $1.00 per yard, the entry driver being paid also the mining rate per bushel for the coal taken out of the entry.

Taking down the roof coal in order to give greater height for the entry at present costs 15 cts. per yard; digging drain to the limestone costs 15 cts. per yard.

The "break throughs" between entries cost 50 cts. per yard and cost of digging coal at mining rates. The tracks in the entries are of sixteen pound T iron or steel rail laid on ties, two feet apart, of three by four inch timber. When driving entries, the miner makes a cut called a "bearing-in," three to three and a half feet in depth, the width of the entry and under the coal. He also makes a cut at the side of the entry, three feet wide and five or six feet in depth, the entire height of the coal. The coal is then broken down by wedging or by blasting with powder. It is then loaded on the wagons and after this is done, the slate is broken down, loaded on wagons and hauled to the dirt dump.



PLAN
SHOWING METHOD OF WORKING

Scale of Feet
0
30
60
90
SOLID COAL
N. 25 E. or S. 25 W.
ROOM BEING DRIVEN
Wooden Track
Posts placed in rows 6' apart 3 in. each row
ROOM DRIVEN UP AND RIB PARTIALLY DRAWN
Wooden Track
ROOM DRIVEN UP AND RIB DRAWN
250'
12
21 ft.
18 ft.
33
Butt Entry N. 65 W. or S. 65 E.
Eng. by American Bank Note Co. New York.
Toward Main Entry →

The rooms, or working places, are turned off the butt entries about thirty feet apart; they are worked in for the first 15 to 21 feet only seven feet wide; they are then widened on one side to a width of 21 feet, leaving a coal-pillar called a "rib," twelve feet thick. The track is laid straight up the side of the room from the opening off the entry. All of the room as it is worked up, except the portion on which the track is laid, (about 7 ft wide) is filled with the refuse of the coal and the slate, called "gob," posts being first set in rows, 6 feet apart, three in a row, to support the roof. If the roof is bad posts are of from four to eight inches in diameter, 5 to 5½ feet in length, and cost, delivered at the mines about $6 per hundred. In one room about six hundred and fifteen posts would be used. "Break throughs" are made in the ribs, about every thirty yards into the next room.

The track laid up the side of the room is made of wooden rails, two by four inches. The road in the mouth of the room, however, and the turn-off on the track in the entry, are made of T iron. The miner working in a room, works much the same as in an entry, save that where the coal is blasted, the cut at the side of the room is not made.

Blasting is used nearly altogether. The amount of coal broken down is from 180 to 200 bushels of screened coal. The rooms or working places are driven up about 80 yds from the entry, at this distance meeting the next entry. It usually takes the miner, one man working to a room, eight months to a year to drive up one room. When a room is driven up, the miner then draws back the rib, putting in posts from time to time so as to support the roof while he is working under it.

In drawing a rib about sixty or seventy posts are required. Thirty or forty of these are ones that were already used in driving up the room; these are all lost in the drawing of the rib.

In the driving up of a room, about eleven hundredths of an acre of coal is mined, amounting to about 13,000 bushels of screened coal, and in the drawing of the rib, about six hundredths of an acre, making about 7,000 bushels of screened coal. The rib is drawn back to the point at which the room was widened. In the mining of six rooms and their ribs, about one acre of coal is mined, making about 120,000 bushels of screened or lump coal, about twenty-four thousand bushels of nut coal and about 24,000 bushels of slack.

The wooden roads in the rooms are laid by the miners themselves (see page 386.) At some places where it is claimed that the roof is bad and will not support the hill to draw out the rib, the room is widened on both sides of the road, leaving the road in the center and throwing "gob" on both sides. The room is started 25 feet wide and gradually widens out, until at the end it is about 30 feet in width, leaving a rib of an average thickness of five feet, which is lost.

Coal-Cutting Machines.

At several mines in the district coal-cutting machines are in use. These machines are driven by compressed air, carried in an iron pipe from the air-compressing engine at the mine mouth to the workings. The machine most in use is known as the "Harrison." It is simply a compressed air cylinder driving a piston rod to which is attached a steel bit two inches in diameter.

The bearing-in under the coal is made by the chipping out of the coal by the striking of this bit. The bearing-in is 4 to 5 feet in depth and can be made in two hours, from ten to fifteen machines being required to operate a mine whose output is 18,000 bushels per day, the machines running without stopping, day and night.

At W. P. Rend's mine, 25 to 30 machines are employed. They are furnished with compressed air by two engines, the larger one of which, a single engine, has a 24 inch cylinder, with a 48 inch stroke; the other engine having 18 inch cylinders, 36 inch stroke. The pressure of air at the engines is usually 60 pounds to the inch; ten pounds of this pressure is lost by friction. A battery of seven boilers is used for these engines, burning about 25 tons of slack daily. The present cost of mining is 14 cents per ton for cutting and 38 cents per ton for loading, making a total of 52 cents per ton for actual mining. Added to this the expense of compressing air, laying pipes, and repairing machines which will amount to probably ten cents per ton, the total reaches 62 cents per ton against 71 cents, the present mining rate (August 1886.)

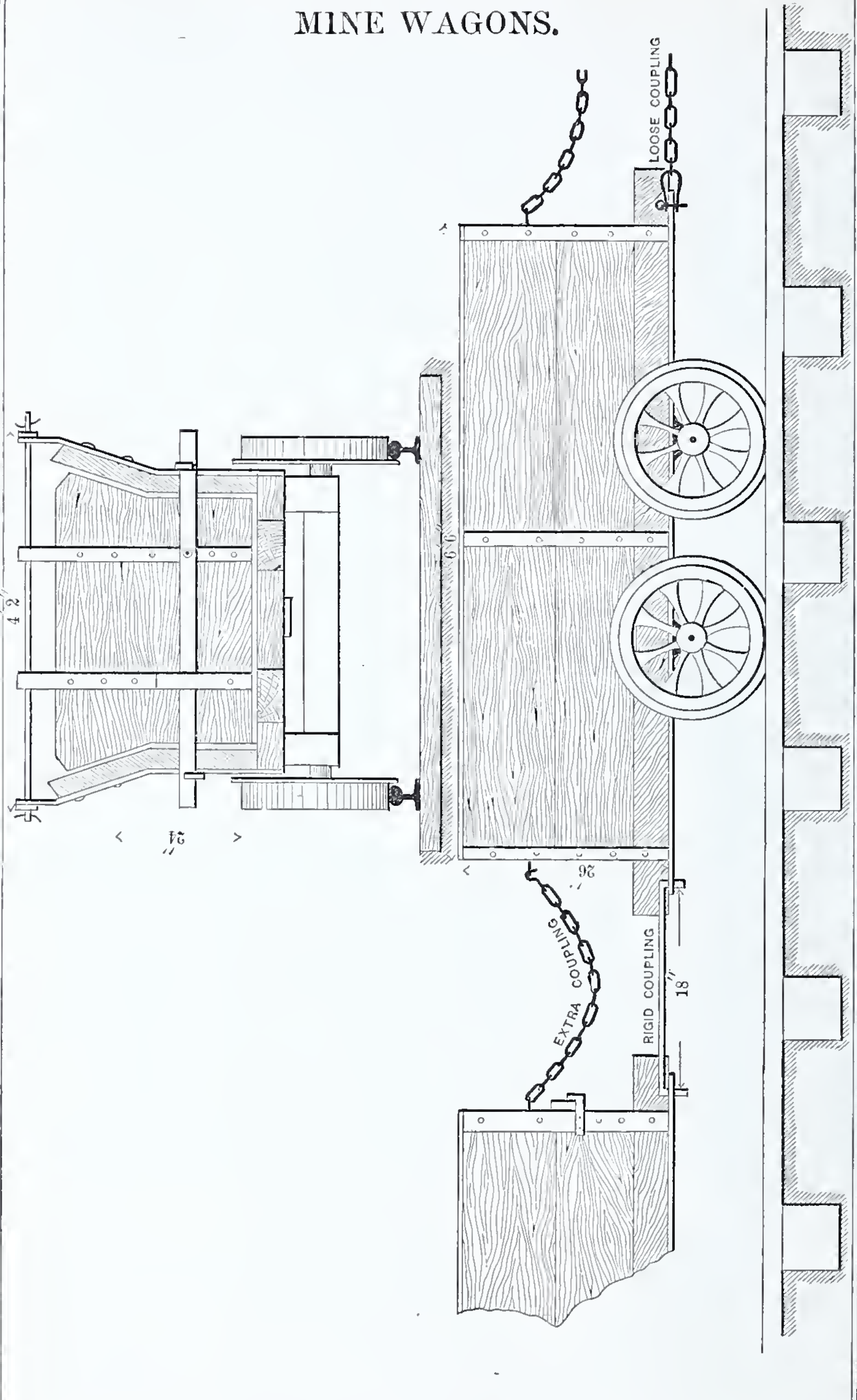
These machines are now only used to drive up rooms, it having been found that they could not be successfully used in drawing ribs.

Rolling Stock.

With the exception of the Saw Mill Run region, the pattern of mine wagons is the same throughout the district. The bed of wagon is of 1½ or 2 inches oak; 2 to 2½ feet in depth and at the bottom of the wagon is about 4 inches less in width than the gauge of the track, many different gauges being used, varying from 3 to 4 feet. They are from six to eight feet long. From about halfway up the bed to the top of it, the sides are flared out making the wagon about a foot wider at the top than at the bottom. To the bottom of the bed are fastened the axles on which 18 inch cast-iron wheels are used. The back of the car is not extended as high as the sides of the wagon by about 8 inches, in order to allow the miner to readily load his coal over that end. The front end is always as high as the sides of the wagon and is even sometimes extended above them. The end is in the form of a door, swung to an iron bar across the top of the wagon and fastening at the bottom with a heavy iron latch. These wagons hold from 28 to 35 bushels of screened coal, 5 to 7 bushels of nut, and 5 to 7 bushels of slack.

On some of the cars usually at places where the mine grades are steep, and the hauling done by mules, a brake is used; but at a great majority of mines the wagons are braked simply by sprags placed in the wheels. On this style of car, loose wheels are mostly used; fixed wheels have been tried, but could not be made to work, owing to the

MINE WAGONS.



width of the gauge, and the sharp turns that are made from entries into rooms.

A mine car costs when new about $35 ; the wheels last from 2 to 5 years ; the woodwork from 4 to 6 years.

Couplings used are of two kinds, rigid and loose. Rigid couplings consists of a clinch hook 18 inches long, made of 1½ inch iron ; the loose coupling consists of 6 or 8 chain links with a hook or clevis-bar at each end. In addition to these, safety chains are sometimes added to the coupling, being fastened to the sides of the car ; these are only used on inclined engine planes.

Wagons built in the shape of an oblong box made water tight, are often used for hauling the water from the mine. Plate page 390, shows the common style of wagon used for hauling coal.

At Hartley and Marshall's mine, and at one of Gray & Bell's mines, a different style of car is used. The gauge of the track here is but 24 inches. The bed of a car is simply an oblong box, 6 ft. long and 4 ft. wide, 20 inches deep with fixed wheels. Mine cars weigh from 800 to 1,300 lbs.

Much of the hauling of coal underground is done by mules. On the average grade in our mines one mule is able to draw about four loaded wagons, each of them containing a little over a ton of coal. There are many grades, however, where it is impossible for a mule to pull more than one car ; and there are others, where the grade is so favorable, that one mule may draw as high as seven loaded cars, bringing the empty cars back over the same road.

It is almost impossible to give exact figures, as to the cost per bushel of hauling coal by mule power, as in no two mines do we have the same conditions, such as grades of roads and length of haul. However, for mines having an average output of 16,000 bushels per day and where they have been operating for some years, from 12 to 20 mules would be required for the inside haulage. Where the mine is a new one, probably for the first two years, about 5 to 6 mules would be required. Taking a mine, having an output of 16,000 bushels, probably an average of 15 mules would be required, and employing 15 drivers, the total cost of haulage would be $40.00 per day, or about 6 cts. per ton.

A good mule for mine work costs about $175.00, and their average life for mine work is about 7 years. In almost all of the large mines, which have been operated for any length of time, some system or other of underground haulage by means of wire rope and stationary engine, is in use. Plants in use are of several different systems and indeed it might be said that at no two mines is exactly the same system or the same devices in use.

Wire Rope Haulage.

The conditions at different mines being so varied, this system of hauling can be divided into three distinct systems. The first of these, the most simple, is that of the engine plane; a name given where the cars are to be moved but one way by the engine and wire rope, the grade the other way, either for the loaded cars out or the empty ones in, being sufficient to carry them and drag the rope with them.

This system can only be used when a grade of not less than 13 inches in a hundred feet, for the loaded car, or 16 inches per hundred feet for the empty car travelling by gravity, can be obtained.

The length of the road, with the greatest average dip obtainable in our coal should not be much over 5000 ft, as greater than this length of rope becomes too heavy for the wagons to drag. For very short distances, with the small amount of rope required for it, an engine plane would work successfully on a much less grade. No fixed rule, however, can be given as to the exact grades or various lengths on which the engine plane system could be successfully used.

With the slight dips usually obtained in the Pittsburgh coal the engine plane should be nearly, if not quite, a straight road. The ideal grade would be one that became steeper as it reached the bottom of the plane, as the resistance becomes so much greater with the increased length of rope carried by the train. From 25 to 45 cars usually compose the trip train or "dilly" as it is called. These planes are usually located where the grade is down toward the mine workings, and the engine can be placed at the pit mouth. They usually end on a slight up grade obtained either by the change in the dip of the coal at that point or by turning the plane to such an angle that enough grade is obtained to stop the trip nearly by their own weight without much assistance from the engine and rope.

While most of the planes in use are for the hauling of the loaded wagons from the mine out, several are in successful operation on long planes outside, where the grade is not great enough or the curves not too many to successfully operate a simple gravity plane.

At Jos. Walton & Co's. 2nd Pool mines can be seen an engine plane drawing the loaded cars from the mine. The entire road is nearly 5000 ft. in length, having a slightly undulating grade but giving a fall of 75 ft. for the entire distance. About thirty cars are drawn at a trip, about 20 minutes being required to make the round trip. The coal is drawn from two points by alternate trips; one point being only about 3000 feet from the pit mouth.

Coal is taken from these points alternately. The entries on which this plane is located, are shown on the large plan the average amount of coal hauled over this road, per per day, being about 19,000 bushels.

At Hartley and Marshall's Enterprise mine on Saw Mill run, another very successful engine plane is operated; the average grade of the plane at this mine being 21 inches per hundred feet, the plane about 4,500 feet long and gauge 24 inches, and using a rail weighing 25 pounds to the yard.

The round trip at this mine is made in nine minutes, having a daily average output of about 20,000 bushels About twenty-five cars are drawn at a trip, each with a load weighing about 4,400 pounds. This plane is operated by a single acting engine with fourteen by thirty inch cylinder. The rope, of 9-16 inch steel, is wound around a five foot drum; the engine is situated at the top of the plane, with the gearing in the proportion of 1 to 2½.

At Foster and Clark's mine on the Monongehala river, two engine planes are operated by one engine, the engine being placed at the summit and the planes descending both ways from this point. Great care is taken with the rope and all machinery of an engine plane, as the breaking of a coupling or of a rope may do an enormous amount of damage. The ropes are usually tarred every three months.

A device called the "devil" or "growler," used on almost all engine planes on the up grade, consists of a pointed bar of iron, hooked to the last car of a trip; the pointed end dragging on the ground. If, by any means, the trip starts backwards, the growler catches on the ties and either stops the trip or throws the last car or two off the track.

Tailrope System.

This system is the one most commonly in use; it is undoubtedly the best for all conditions. The tailrope system is in use on roads with many turns and curves, and over any grades found in our coal districts, many of the grades being undulating.

For operating under this system two separate drums and two ropes are required. The engine is usually placed at the mouth of the mine and consequently draws the loaded cars directly to it. The rope thus hauling the cars toward the engine is called the main rope.

The tailrope is generally somewhat lighter than the main rope, and of twice the length. It runs from the drum of the engine at the side of, under, or over the track, until the end of the road is reached, where it passes over a wheel, called a bull wheel, of from four to eight feet in diameter. It is then attached to the rear end of the trip, and on the trip being hauled out by the main rope, the tailrope is drawn out with it, serving as a brake to the trip, when the grade out is a steep one.

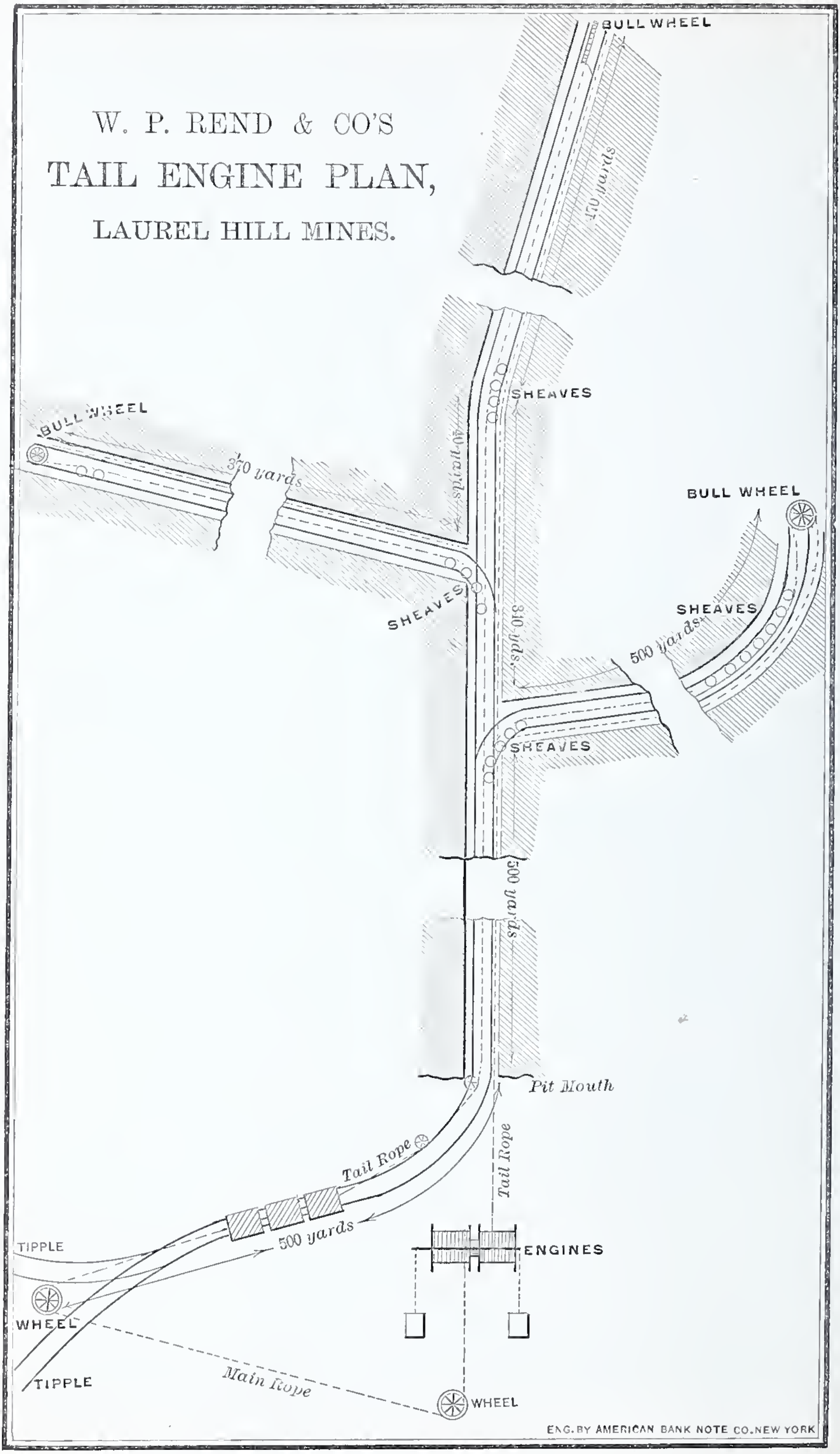
In each drum of the engine are placed strong brakes, so that on the signal the trip can be almost instantly stopped by the engineer. Under the tailrope system the planes may be of almost any desired length. There are planes in successful operation, three miles in length and requiring nine miles of rope to operate them. A tailrope plane of this length is in use by the Birmingham Coal Co. at Pittsburgh.

While the road is without curves it is with undulating grades. A large portion of this road is outside; from 60 to 70 cars are hauled at a trip, traveling at the rate of about 8 miles per hour. The main rope on this road has a diameter of $\frac{7}{8}$ of an inch; the tailrope a diameter of $\frac{3}{4}$ of an inch, both of steel and seven wires to the strand. The main rope is supported in the middle of the road by eight inch rollers, 25 feet apart; the tailrope is carried along the side of the plane on rollers set in frames or hung from the roof or side of the entry. The plane is operated by an 80 horse power, double acting engine, 14 by 36 inch cylinder, making from 65 to 70 revolutions per minute.

At W. P. Rend & Co's. Laurel Hill mines, a very complete Tailrope system is in use (see page 396.) The engine is here situated at the mouth of the drift and draws the coal from three different portions of the mine, making the trips alternately. From 18,000 to 25,000 bushels of coal are hauled daily. The main rope on this road is of $\frac{7}{8}$ inch steel, while the tail rope is but $\frac{5}{8}$ inch. The plane is operated by a double-acting engine, ten by twenty-two inch cylinder, drums, 5 feet in diameter. 30 to 45 wagons are hauled at a trip. Six minutes are required to make a round trip. The grades of the roads are undulating ones. The plane contains a number of curves; the coal is delivered at two tipples alternately, and the longest haul of the engine is 5500 feet.

After a trip is drawn out from one portion of the mine, the empty cars are taken back to the same place, the rope is uncoupled at the joints, purposely made at the point where the road turns off from which the next trip is to be drawn; the rope is then coupled to the two lengths of rope, which have lain idle during the last trip, and then passes over another bull wheel at the end of this road.

At some mines, the tail rope system is employed having an engine at each end of the plane. Where the haul is a long one, with undulating grades, this is perhaps the best



W. P. REND & CO'S
TAIL ENGINE PLAN,
LAUREL HILL MINES.

ENG. BY AMERICAN BANK NOTE CO. NEW YORK

method. At the Venture mines, a plane using a main and tail engine is employed; the tail engine is located at the side of the entry, about 6,000 feet from the mouth of the mine, where the main engine is located. A ventilating shaft is placed at the engine to take the exhaust steam and smoke from the furnace out of the mine.

But one curve is made by this plane; the ropes are guided by this curve on iron, wood-lined sheaves of about 18 inch diameter, placed outside of the track. On this plane the tail rope and main rope are connected by a chain passing under the trip, thus making it practically one rope. Owing to the heavy strain on the main rope at this colliery, a 5 inch steel one is used but one year as a main rope; it then lasts for some years as a tail rope.

The Endless Rope System.

At some of the mines in this district a system of wire rope haulage without the use of drums has been adopted; this is done by running the rope around the usual bull-wheel at the far end of the plane, while at the engine the rope is given one or two turns around an almost similar wheel, this wheel being turned by the engine and thus giving motion to the rope. The rope otherwise works exactly like the simple tail rope system.

Probably the only advantage of this system is that one third less rope is required than under the tail-rope system; but this advantage hardly compensates for the surplus power required to operate the endless rope system, owing to the extreme tension at which the rope must be kept, in order to keep it from slipping on the wheel at the engine. It is also quite difficult to operate this system on a curved plane. Much difficulty is also experienced with the contraction and expansion of the rope owing to difference in the temperature, a great expansion of the rope causing it to slip over the wheel and a contraction breaking or straining the rope.

At the Imperial Coal mine on Montour's run, a very successful endless rope system is employed. Here the rope is really an endless one, moving all the time and in one direction on a double road, the rope passing in one entry which is used to carry the empty cars into the mine and passing out a parallel entry, through which the loaded cars are drawn out. The trip itself is not coupled directly to the rope but to a patent "grip car." This car is a heavy one, supporting two rubber-lined four-foot sheaves; the rope passing with a half turn around these sheaves causes them to revolve when the trip is not in motion; but by means of a lever operating brake-bands on the sheaves, the revolving is stopped and the grip car moves along with the rope, drawing the trip with it. Under this system the trip may be stopped anywhere. The wagons are not formed into the trip at any one point, as is required under other systems, but are collected from different points along the route.

Mine Locomotives.

Locomotives are not used extensively in the mines where mining is being prosecuted, though they are often used in entries for hauling the coal, when the coal has all been worked out in that hill. At but one mine, that of Hartley and Marshall, is a locomotive used in the same hill with the workings. At one other mine, that of W. H. Brown & Sons, a compressed air locomotive is used. The locomotives used for drawing mine cars through the abandoned entries are generally from eight to twelve tons in weight. Where wire rope has been placed to draw the coal instead of mule power, for a mine of 15,000 bushels capacity a saving of from eight to twelve mules generally results the cost of which including the employment of drivers, would amount to about $20.00 per day. The entire rope plant varies in cost from $5,000 to $10,000, while the daily expense of operating it will amount to from $5.00 to $10.00. In very long planes, however, while the expense of operating them is practically nothing more than on short planes, twenty-five or thirty mules would perhaps be required to do the work done by the engine. The cost of the entire inside haulage and handling of coal in this district varies from 8 to 20 cts. per ton.

Drainage.

Few mines are being worked that do not, in the main, have natural drainage, there being, of course, portions of every large mine that are not so favored. Some few mines are altogether artificially drained; this is done either by steam pumps or siphons, drawing the water from some one point where it is collected in a basin called a sump. Where pumps are used, steam is conveyed from boilers located either at the surface or at the foot of a ventilating shaft where a furnace is placed.

At W. P. Rend's Laurel Hill mines and the Jumbo Coal Co. mines, both of which, using compressed air for the mining machines, use the same for operating the pumps. At many of the mines siphons are successfully used to drain the mine; they are very successful under certain conditions: a fall from 30 to 50 ft must be had from the long arm of the siphon at the pit mouth. The highest point over which the siphon passes should not be much more than 20 ft in elevation above the point at which the water enters the siphon. Siphons will operate successfully for any distance under 4,000 ft; for a longer distance, unless a very large pipe be used, the friction would be so great as to destroy its usefulness. While no fixed rule can be given as to the smallest diameter of pipes that will operate successfully as siphons for given distances, probably not less than a one inch pipe could be used for a siphon over 1,000 ft. in length.

At different mines the conditions are varied for the reason that at some mines the water will contain many impurities and will deposit much sediment while at others it is perfectly pure. Great care must be exercised in the laying of siphon pipe, each joint being perfectly air tight. Lead pipe is often used, as it is the only material that is entirely impervious to the action of sulphur water; they are, however, very expensive and easily crushed or flattened out, thus preventing the flow of water. Ordinary iron tubing is generally used, but in mines where there is much sulphur in the water, they are quickly destroyed, sometimes lasting but a few weeks. Galvanized iron is often used and will last much longer than the ordinary iron tubing. A small hand pump is placed either at the outlet or on the summit of the siphon to exhaust the air and start the flow of water.

The water is usually collected in a sump placed at some point in the mine where all of the coal in that vicinity will be naturally drained by it. Owing to the large amount of outcropping in this bed of coal, it is often possible to draw the water out of a mine by means of drains, even where the dip is away from the outcrop. This is done by blasting drains through the limestone under the coal. Blasting limestone costs about fifty cents per cubic foot, dynamite being generally used in nearly all mines in the district where local swamps or rolls occur. If these are not too deep, the water is either exhausted by siphon or hauled out, until the coal in the swamp is mined out, and then the roof is taken down in the entries, and the road is raised so that the drain on the entry will carry the water past the swamp. Where the swamp is more than twenty feet in depth, however, a water course is generally driven irrespective of the cleavage of the coal, along the bottom of the swamp.

These large swamps are usually much the shape of a trough rather than a basin, the sides of the trough having a dip of from one to three hundred feet, while the swamp or trough itself has an inclination, generally to the southwest, of not more than one in one hundred feet.

If not possible to extend the entry driven along the bottom of this swamp to the out-crop, a siphon or pump is used to draw the water from the lower end of the entry. A swamp entry is shown on the large plan of Jos. Walton & Co.'s mine. This swamp entry drains about 40 acres of coal and has been extended to the outcrop. It is used as a hauling road, as it gives the grades in favor of the load. The butt entries marked on the plan, Nos. 3, 4, 5, and 6, dipping toward this swamp entry, have a much heavier depth than usual, parts of them having a dip of seven feet in one hundred. This swamp probably marks a synclinal axis.

At the Amyville colliery, lying at the apex of the anticlinal roll, the dips of the coal are quite peculiar, and the drainage very irregular, no definite dip being found for any great distance, and the whole mine being, in fact, a series of local swamps and rolls. The entire mine is drained by siphon, a two inch pipe and a three inch one being in use, both branching out inside the mine, and drawing the water from several points. This mine is an unusually wet one, there being only from 50 to 80 feet of covering over the coal and every break throws surface water into the mine.

Ventilation.

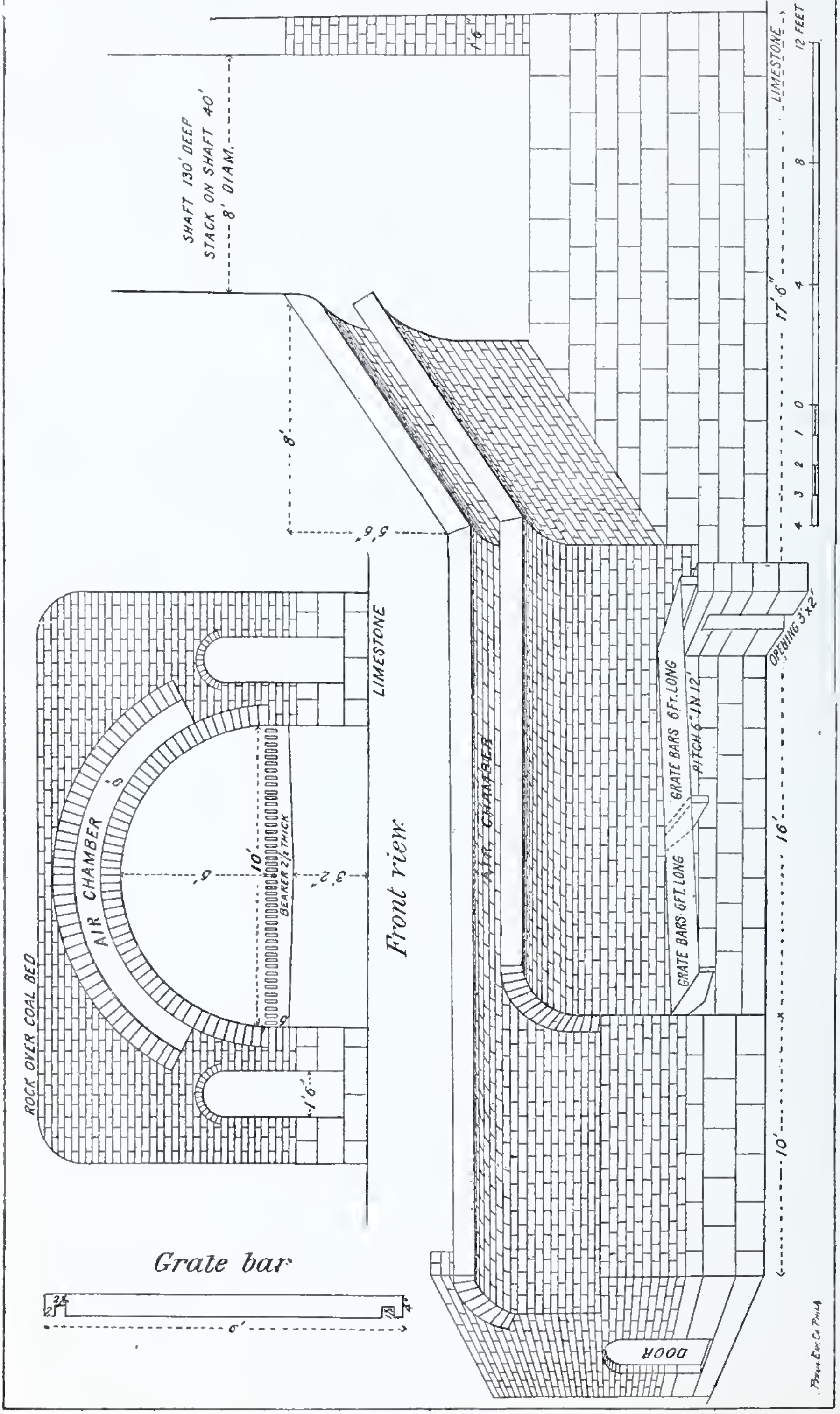
Almost all of the mines in this district are ventilated by artificial means, furnaces or fans being used. Furnace ventilation is most generally used. The furnaces are usually located at some point in the mine where the surface is reached by a shaft 50 to 100 ft. in depth, and yet not too far from a drift-opening to daylight where it can be handily reached, in case of an accident. A plan of furnace used for ventilation is shown on page 402. A good furnace costs, including shaft, from one to two thousand dollars.

Fans.

Where fans are used for ventilation a good one of 12 to 15 ft. in diameter making 60 to 70 revolutions per minute is amply sufficient for the ventilation of any mine in the district. In fact, until within a very few years nearly all the mines depended entirely on natural ventilation and some few are yet well ventilated in that way. That portion of Jos. Walton & Co.'s 2nd Pool mines which is worked on the single entry system, shown on the large plan, depends on natural ventilation alone; nearly all the entries here having drift openings at both ends and having considerable difference of level between the ends, varying from 30 to 100 ft., a large naturally circulating current of air is produced.

The mines in this district within the last few years have passed beyond the first "hills" where many openings to the outcrop could be obtained and their workings are now

Ventilating Furnace at Walton's 2nd Pool mines.



located in larger bodies of solid coal, thus making artificial ventilation a necessity.

Heretofore but little firedamp or other dangerous gases have been met with in the mining of coal in this district. In the mines *now* reaching into larger areas of solid coal with little outcropping, dangerous gases are frequently encountered and in considerable quantities.

Mine Employés.

The following is a list of the employés usually required in a mine having a capacity of 15,000 bushels per day:* Two hundred miners, paid at the rate of 2½ cts. per bushel; six to fifteen drivers, at $1.75 cts. per day; two to six door trappers, at $1.00 per day; three roadmen at $2.00 per day; one Boss Driver at $2.50 per day; Fire Boss, at $3.00 per day; Mine Boss at $3.00 per day; Engineer at $3.00 per day; Blacksmith at $2.50 per day; Blacksmith's helper at $1.75 per day; Checkman at $2.50 per day; Checkman's assistant at $2.00 per day; Greaser at $1.50 per day; Dilly rider at $2.00 per day; Car couplers, *three*, at $2.00 per day; Weigh master at $3.00 per day; and two to four assistants at Tipple at $2.00 per day. The fire boss and mine boss are required to have passed an examination and hold a certificate, as to their competence to discharge their duties.

Transportation from the Mines.

The coal is transferred from the tipple to market either by railroad or river; when transported by rail, it is loaded at the tipple into cars holding fifteen to twenty five tons. Where it is to be shipped to some local point, it is loaded in "hoppers" or "dumps," cars built with a moveable or drop bottom, through which the coal is unloaded into bins underneath the track. Where the shipments are for eastern trade, or for points less than two hundred miles west, flat cars are used carrying from 20 to 25 tons of coal. To points farther west, the railroad companies usually require the coal to be loaded in box cars, as they can be used both ways.

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*Wages estimated for August, 1886.

At many of the mines the coal is hauled some distance in the mine cars from the mines before it is loaded on the river or in the regular railroad cars. On the Castle Shannon Railroad the mine cars are drawn from the mines a distance of 4 or 5 miles into the city of Pittsburgh and the coal unloaded directly from them into the bins of the company at their coal yards.

At Gray & Bell's mines, by means of an inclined plane and tunnel, their coal was delivered in the ordinary mine wagons at the mills of Singer, Nimich & Co., on the South Side of Pittsburg; this was previous to the introduction of natural gas, however.

On the Saw Mill Run R. R , coal is loaded at the tipples into small hopper cars, which are then drawn a distance of three miles to the river and there unloaded into barges, by means of a swinging platform, by which the entire car is lowered close to the boat in which the coal is to be loaded.

Coal is carried on the river in "boats," "barges," and "fuel barges." Barges are the most substantial craft, and are built of heavy timber, the sides being of 6 by 12 pine timber and the bottoms of 3 inch plank, all framed on oaken streamers, 3 by 9 inches, set 18 inches apart, the whole barge being bolted together and well calked.

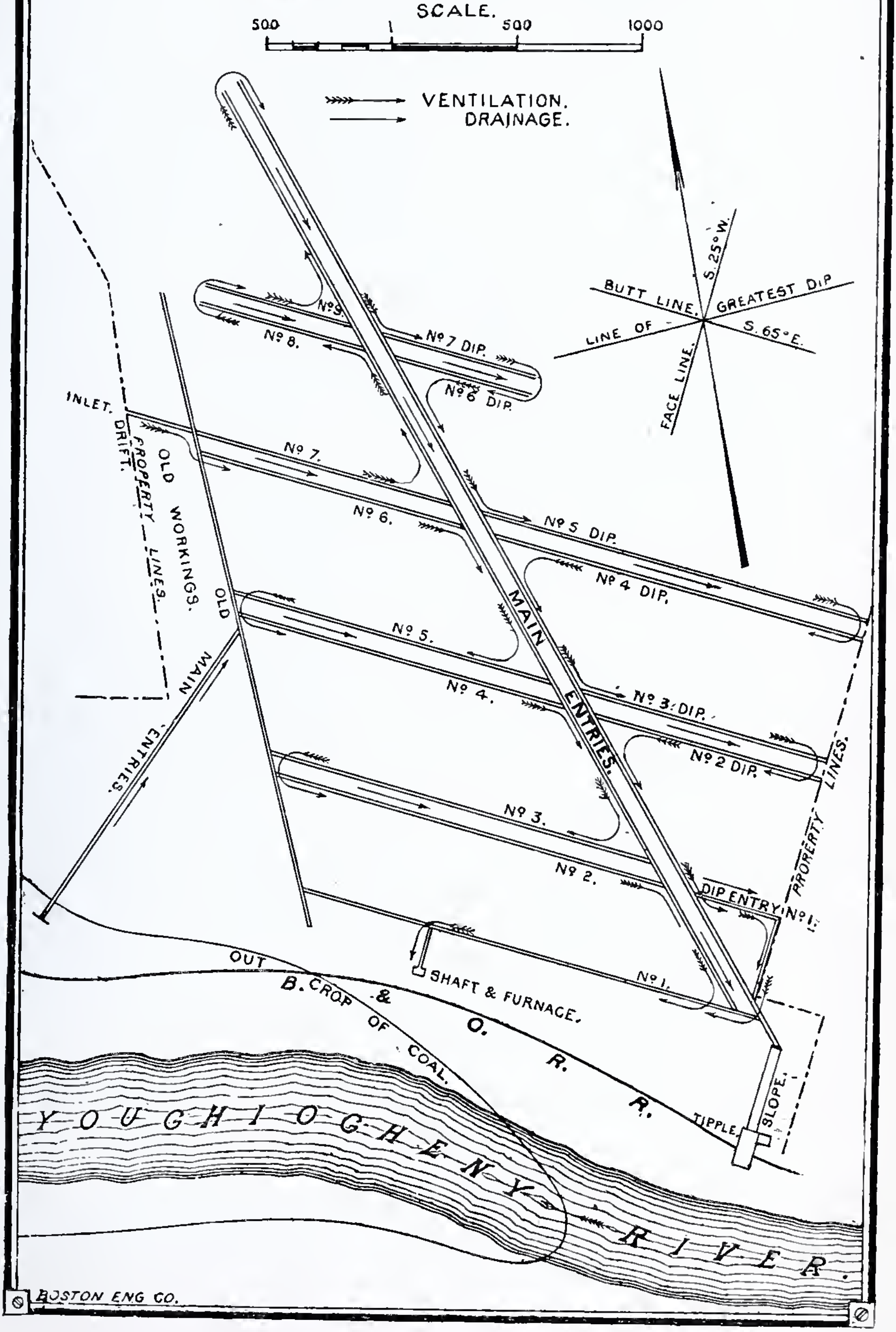
The bow and stem are exactly alike, being curved from the bottom up, but carrying out the same width for their entire length. They are built from 24 to 30 feet in width and 120 ft. in length and 7 ft. in depth, and when loaded draw from 4 to 6 ft. of water.

A barge will hold about 12,000 bushels; barges last, unless meeting with some severe accident, from 10 to 12 years; they cost about $1000.

Boats are much larger than barges and are built with less care, with 1½ inch siding and 2 inch plank bottom with streamers of the same sizes as in barges. They are generally 24 ft. wide, 160 ft. long, and 9 ft. deep; the ends are not curved; they are loaded to draw from 7 to 8 ft. of water, and carry about 24,000 bushels of coal. They cost about $650. and are generally sold with the coal, in the

YOUGHIOGHENY SLOPE MINES
NEAR
West Newton,
B. & O.R.R.

McCULLY & TAYLOR.



BOSTON ENG. CO.

lower river markets, it costing more than they are worth to bring them up the river.

Fuel barges are built just as an ordinary barge, but smaller, being from 18 to 20 feet in width, 120 feet long and carrying 8,000 bushels of coal. Almost all the coal. transported by river, is brought through one or more locks on the Monongahela river, for which toll is paid at the rate of 90 cts. per thousand bushels, for each lock. Almost all of the coal comes from the 2nd or 3rd pools. The average lockage paid would probably amount to $250 for each acre of coal. Towing coal costs 1½ cents per bushel from Pittsburgh to Cincinnati or Louisville, and about 3½ cents to New Orleans.

Coal lands cost from $75 to $400 per acre, according to location. The entire cost of opening a mine here, including the plant, is from $4,000, to $25,000, probably $10.000 being a fair average.

The capacity of mines in the district varies from 5,000 to 25,000 bushels of coal per day.

Slope and Shaft Mining.

There are but few slope or shaft openings for the operating of coal in this district. There is but little difference in the cost of opening and operating as between shaft and slope and but little difference in the advantages and disadvantages of either.

The drawing opposite shows a plan of the Youghiogheny Slope mines. These mines were originally opened by a drift about a half mile below the present opening; but owing to the heavy dip of the coal it was abandoned and a slope driven at the south-eastern corner of the tract. This slope has a total length of 250 feet, the bottom being 87 feet lower than the top which is level with the tipple, the tipple being 26 feet above the B. & O. Railroad and about 65 feet above low water of the Youghiogheny river. The slope is operated by a small double engine at the top of the slope, drawing two cars up at a time, the empty cars running down the slope by gravity being controlled by a break on the engine. The dip of the coal in this mine is exceedingly regular. Comparatively few local swamps or rolls occur.

All of this mine lying west of the main entries drain to them, they themselves having a sufficient dip to drain them to the bottom of the slope. These main entries were driven in a direction as far eastwardly as would allow them to be self draining. All of this field of coal lying to the east of the main entries dips steadily away from them. This portion of the mine lying to the dip, as it is called, is worked more in the summer than in the winter season, as during the former but little water is produced and what is found can be readily hauled to the drains on the main entry. It is proposed however, to sink a shaft at the north-eastern portion of these dip workings and pump the water through it to the surface. The water is forced from the foot of the slope to the surface by a pump placed at the bottom of the slope. At the pump is placed a barge sump or basin sunk in the limestone which is more than sufficient to hold the water accumulated during the working hours; this water is then pumped during the night. The pump is operated by the steam conveyed from the boilers at the top of the slope that are used for operating the hauling engine during the day. This mine is operated on the double entry system and ventilation is secured by means of a furnace located at a shaft shown on plan. The capacity of this mine is about 15,000 bushels of lump coal per day. The coal is hauled to the foot of the slope.

Shaft and slope sinking cost from $5 to $12 per foot, perpendicular, when the depth is over 100 feet. From 50 to 80 feet per month is the progress usually made. Usually no timbering, except for fifteen or twenty feet at the top and bottom, is required, the rock usually being strong enough to be self-sustaining. While the mines operated by slopes are few; and still less are those operated by shaft; almost all of the mines having furnace ventilation, use shafts. These shafts vary from 6 to 10 feet in diameter and from 40 to 200 feet in depth, and are generally driven from the surface down. After a depth of 50 feet is reached, it is generally necessary to brattice off a small portion of the shaft and hang a small fire basket in it in order to exhaust the powder, smoke or dynamite fumes, whichever is used, and supply fresh air to the mines. Dynamite is generally used. Sometimes shafts are driven from the mine up; this is advisable where, after having started the shaft, trouble is experienced from water.

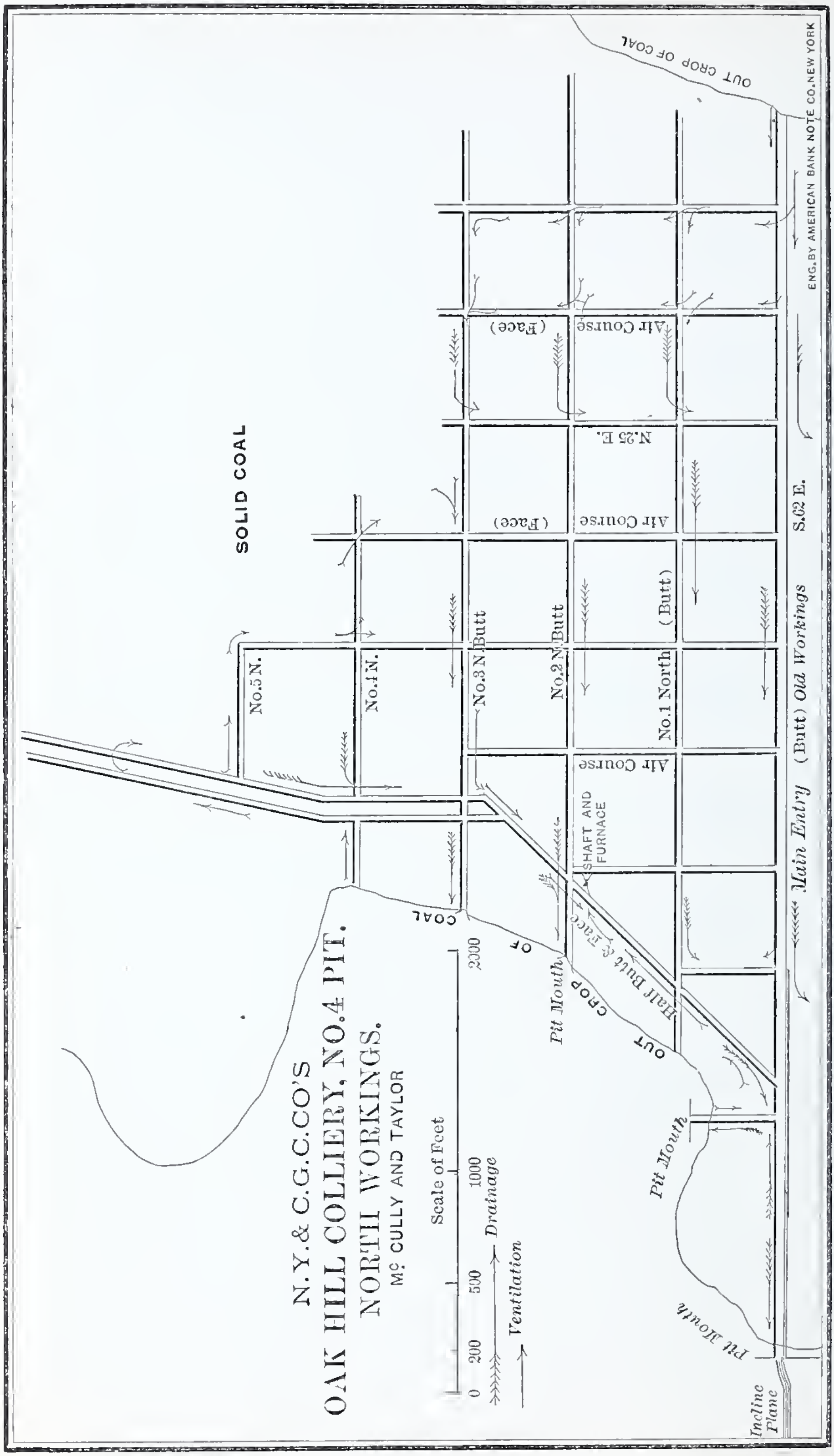
Where the shaft is started from below, it is first driven in an oblong shape and afterwards squared or made circular. Short cross-timbers are placed across each of the narrow ends of the "oblong." Each of these ends is then bratticed off and allowed to remain open; what material is required to keep the shaft filled up enough to allow the men to stand on to work is allowed to remain.

The surplus material is thrown down through the open space and is carried away in the mine cars; the advantages of this system are the drainage, the ventilation given by complete circulating air passage and the greater ease by which the material can be removed.

But little difference is found in the manner of working the coal in different parts of the district. At one mine, that of the Keystone Coal Co., of the Pittsburgh, Cincinnati and St. Louis railway, a slight variation in system is in use: The butt entries are driven 80 yds, only half the usual distance apart; this is owing to a somewhat unusual steep dip of the coal on the face, the rooms being only turned from one side of each entry and being driven to the next entry. The rooms are always turned and driven to the side of the entry that will allow them to drain into the entry.

At W. H. Brown's Sons Saltzburg mines the system used in moving the coal is one which was originally used at many of the river mines, but is not now generally used. The tipple is built as a railroad one and located at the top of the inclined plane. The coal is hauled on the plane in two "tram" wagons, each holding about 80 bushel of lump coal and the proper portion of nut and slack. These cars are built of sheet iron and are made in such shape that the coal does not fall out of the wagons by reason of the steep plane.

The "tram" wagons are built with two compartments,



N. Y. & C. G. C. CO'S
OAK HILL COLLIERY, NO. 4 PIT.
NORTH WORKINGS.
Mc CULLY AND TAYLOR

ENG. BY AMERICAN BANK NOTE CO. NEW YORK

one for lump coal and one for slack. Near the foot of the plane one of the compartments is opened by a lever working automatically and the slack and nut coal are allowed to drop out into a hopper, from which it is conveyed to a separate tipple and either loaded on barges or used for coaling the tow boats. The "tram" wagon is relieved of the lump coal on the simple dumping arrangement placed on the foot of the incline and so fixed that it can be moved up or down according to the stage of water. While this style of operating has been almost entirely done away with, it has still some advantages, particularly on very steep planes where a great amount of coal is lost by falling off the wagons. Another advantage is that, with the two cars alone, traveling on the plane, it is possible to keep a much closer watch on the couplings and so reduce the liability of accidents that always exists to the ordinary mine cars used on the inclined planes. On the other hand, extra men are required to operate the system and a heavier rope is required. The dumping of the coal twice is damaging to it.

The plane here spoken of is operated with a hemp rope well tarred.

At the Jumbo Coal & Coke Co.'s mines of the Pittsburgh, Cincinnati and St. Louis Railway, a very complete plant of mining coal may be seen; this mine has been operated about three years and is worked on the double entry system. The main entries are driven on the face of the coal S. 25° W. and have a regular and considerable dip toward the workings. The coal is drawn out on the main entries by an endless rope; this rope is operated by a double acting engine, ten inch cylinders, with 14 inch stroke, making about 200 revolutions per minute and consuming about five minutes in making a round trip. The plane is about half a mile in length and sixteen to twenty cars are drawn at one trip.

In this tract of coal there is about 900 acres having but very little outcropping; the mine is operated on the double entry system, and is excellently ventilated by means of a fan placed at the mouth of one of the main entries. The tipple on which the coal is loaded has a double set of screens and tracks and can be practically operated as two tipples.

An extra set of screens are here used with bars half an inch apart, thus allowing no coal, smaller than $\frac{1}{2}$ inch to be loaded as slack.

At the New York and Cleveland mine on the P. R. R. at Turtle Creek, is to be seen a very complete operation of the single entry system of mining. The air courses and entries are here laid off with great regularity and have been kept perfectly straight. This mine has an average output of 18,000 bushels of lump coal per day which is hauled in the mine without machinery, although a tail engine plane system of haulage is now being contemplated.

About twenty mules are required for the under-ground haulage; an excellent furnace is here used for ventilation; the circulation of air at the furnace is about 30,000 ft per minute; the air is brought into the mine at several different inlets widely separated and joining together at the furnace after they have passed separately through different workings.

This mine owing to the great amount of outcropping, drains naturally. A plan of this mine is shown on page 408.

Part II.

Mining Methods Practiced by Westmoreland Coal Co., Irwin, Penna.

By A. N. HUMPHREYS, *Engineer.*

Early Discovery of Coal.

When and by whom coal was first discovered or mined in Westmoreland county cannot now be positively ascertained. There are no records, memorials, nor even vague and ancient traditions extant assigning this distinction to any particular individual among the early settlers. There can be no doubt, however, that it was discovered some years before the opening of the Land Office (in 1769) when titles to lands in the New Purchase, * of which Westmoreland county was part, were first granted to settlers by the Commonwealth, John Penn, Governor.

It may not be inappropriate to digress here for the purpose of briefly mentioning that the rich and fertile acres of this old "Mother of Counties" were gained through many a cruel, fierce, and savage struggle, and settlement was consecrated in blood and tears. A full and graphic description of what transpired in those early days reads like a romance. † Of those who afterward became famous, one of the first to explore the wilderness where now is Westmoreland was George Washington, who was sent by Governor Dinwiddie, of Virginia, in 1753, there being then a sort of conflict between the authorities of Pennsylvania and Virginia as to whether the former or the latter was entitled to the land lying between the Allegheny Mountains and Fort

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**New Purchase.*—The name by which the lands were known which the Penn's acquired in November 1768 through a treaty at Fort Stanwix with the Indians of the "Six Nations", and were disposed of by the Divesting Act (the Penn's having sided with the crown and against the colonies in the Revolution) passed June 28th, 1779, when their lands became State property. It will be remembered the lands were not taken from them without valuable recompense.

†See George Dallas Albert's History.

Duquesne, at the forks of the Ohio River—where Pittsburgh now is—and all to the north-west. Indeed, it is well known Braddock started from Alexandria, Virginia, on his expedition against the French and Indians at Fort Duquesne, and after his disastrous defeat, Pennsylvania was undeservedly censured for what was termed her backwardness in rendering him assisstance.

The State of Virginia according to a charter from James the First, 1609, if now allowed as then claimed, would comprise Maryland, most of south-western Penna., Ohio, and all west and north-west up to 54° 40′. This patent was revoked in 1624. Penn's province was from fortieth degree of North latitude "in a straight line westward" to the limits of five degrees of longitude from the Delaware. The authorities of Virginia claimed these five degrees would not reach over the Allegheny Mountains, but later surveys proved conclusively they would and did reach beyond the Monongahela.

Prior to 1769 it was made highly penal, besides being very dangerous, for any one to settle on lands owned by the Indians, or rather not purchased by the authorities from them. Nevertheless, before the time of Pontiac's war (1763) there were many settlers along the roads and around the forts occupying lands which were held without permission, or by what was then called "tomahawk title." Such titles, under certain conditions, were allowed in Virginia, but under the laws of Pennsylvania they were not recognized, and mere occupancy never perfected title.

Some of these settlers held their lands by permits issued by the commandants at the forts, who were authorized to grant such permits, and as the discretionary powers of these officers were not circumscribed within narrow limits it may be inferred they were granted for many reasons. To perfect title to lands taken under either permit or "tomahawk title" it subsequently became necessary to procure a warrant when the Land Office was opened in 1769.

Now it would seem that some of these early settlers must have discovered coal prior to 1767; for the following copy of a permit granted by Gen'l. Arthur St. Clair (the original of which is in possession of Caleb Cope, Esq.) would imply that coal had previously been discovered on a certain stream:

"By Arthur St. Clair, late Lieut. in his Majesty's Sixtieth Regt. of foot, having care of his Majesty's fort at Ligonier.

"I have given permission to Frederick Rorer to Cultivate a certain Piece of Land in the neighborhood of Fort Ligonier, over a certain creek which empties itself into the Loyal Hanning, known by the name of the Coal Pitt Creek— beginning at a White Oak standing on a spring and marked with the letters F × R and running from thence to another Tree marked with the same letters and standing on another Spring called the Falling Spring, and from these two marked Trees towards the sd (said) Coal Pitt Creek supposed to contain two hund. acres, he the said Frederick Rorer being willing to submit to all orders of the Commander in Chief, the commanding officer of the District, and of the Garrison.

"Given under my hand at Ligonier this 11th day of April, 1767.

"Ar. St. Clair."

The road graded by Braddock's army, in 1755, crosses the outcrop of the Pittsburgh coal seam at many places in the ravines along streams. The devious, serpentine course of this road over the wheat fields and through the orchards of Westmoreland can yet be easily traced, part of the way over lands of the Westmoreland Coal Company.

In the English contingent of that army were certainly men who understood how to mine coal and who noticed the coal exposures. Some of these soldiers afterward returned and purchased land, but probably not with the view of becoming shippers of coal; wood was too plentiful in those days. What the settlers sought were wheat and corn lands, the best of which were found where the white oaks grew most luxuriantly. These trees furnished abundant wood to be removed; still, many years have passed since the farmers first began to dig coal at the outcrops, and at several localities drifts are shown said to have been opened from sixty to seventy years ago.

Development of the Irwin Basin.

Coal is mined from only one seam—the *Pittsburgh*—in this basin. Its geological horizon is at the base of the Upper Productive Coal measures, and on the top of the Lower Barren measures.

Very little coal has been shipped westward from here, although it is but twenty-one miles to Pittsburgh and the Ohio river. The only part of the product taken westward is the slack. Coke is made of it at the ovens of Carnegie Bro's and Co., at Larimer, to be used at their Edgar Thompson Steel Works, near Braddock, and other iron works at Pittsburgh.

The Pennsylvania Railroad Co. uses some of the coal on locomotives; but the bulk of it is shipped east by way of that railroad.

Coleman. Hailman and Co., in 1853, mined at their Coal Grove colliery the first coal for railroad transportation eastward. The coal was brought out of the mine in carts holding 12½ bushels each, hauled to the railroad and shoveled into box cars. The rate paid for mining and hauling was 31¼ cts. per ton, or 1¼ cts. per bushel, delivered on the platform by the cars. The rate now paid per ton is 55 cts. The shipments made were small.

In 1854 the Westmoreland Coal Co. was organized by Gen'l W. Larimer, Herman Haupt, Hon. John Covode, John Scott and James Magee—Mr. Covode being elected President. They opened Larimer Colliery No. 1 that year, and the next year shipped 50,000 tons of coal. The following year Coal Grove Colliery, now called North Side, was purchased by them; also Spring Hill colliery, in Allegheny County, from Dixon, Stewart and Co.

In June 1859 Brush Run colliery was purchased. This had been opened in 1857 by Col. Thomas A. Scott, afterward President of the Pennsylvania Railroad Co., Wm. Wilson and Col. A. L. McFarlane.

During the year 1866 South Side colliery was opened. The same year another firm under the style and title "Foster Coal and Iron Company," began operations near Penn station. This colliery passed into control of the Westmoreland Coal Co. by merger and consolidation of firms in 1870.

In 1872 Larimer colliery No. 2 and 750 acres previously owned by the Westmoreland Youghiogheny Coal Co. became the property of the Westm'd Coal Co., by purchase. The Company then owned seven collieries and shipped 350,000 tons per annum.

Development work was begun in 1873 for sinking Westmoreland shaft. The method of operating at this colliery is illustrated and described further on.

In 1874 Osceola colliery, with 500 acres and appurtenances was purchased from the Philadelphia Youghiogheny Coal Co. It is situated on the Youghiogheny river, at the head of navigation, the lands lying partly in Allegheny, partly in Westmoreland county. The coal from this colliery, which is leased to the Osceola Coal Co., is shipped east via Baltimore and Ohio Railroad, or westward, down the river to the Ohio.

The colliery, railroad cars, rights, franchises, &c., of the Shafton Coal Co. was the next acquisition, the purchase being made in 1880.

Spring Hill colliery, then nearly worked out, was sold to Dempster & Co. in 1884.

In the lands embraced in the territory surrounding the Company's collieries there are over 5,000 acres of coal land, of which some 1,700 acres have been mined. The number of tons of coal obtained per acre averages 6,500; or a a total of between eleven and twelve millions of tons for the acreage mined.

Besides that enumerated above the Company owns 4,000 acres more in the north-east end of the basin, near Salem, none of which has yet been mined for shipment, because no railroad reaches there.

The capacity of the three collieries now in operation, Westmoreland shaft, South Side and Larimer No. 3, is upward of a million tons per annum; but a three month's strike, scarcity, of cars, &c., will perhaps limit the production this year to 650,000 tons.

The appended map gives the position of the several collieries, and also those of the Penn Gas Coal Co., and others.

The names of the officers of the Westmoreland Coal Co. are as follows:

Francis H. Jackson, President; Edmund H. McCullough, Vice President; Charles F. Godshall, Treasurer; H. C. Adams, Secretary, and F. Z. Schellenberg, Superintendent.

Classification of Collieries and Outside improvements.

The collieries of this, the Gas Coal region of Westmoreland County, from which the principal cities of the Atlantic seaboard receive coal to manufacture their reasonably cheap and most reliable illuminant, may be classed under three heads:

1. Where the entrance to the mine is on or nearly on the same horizon as the tipple, and the coal comes from a drift on the seam at that elevation.

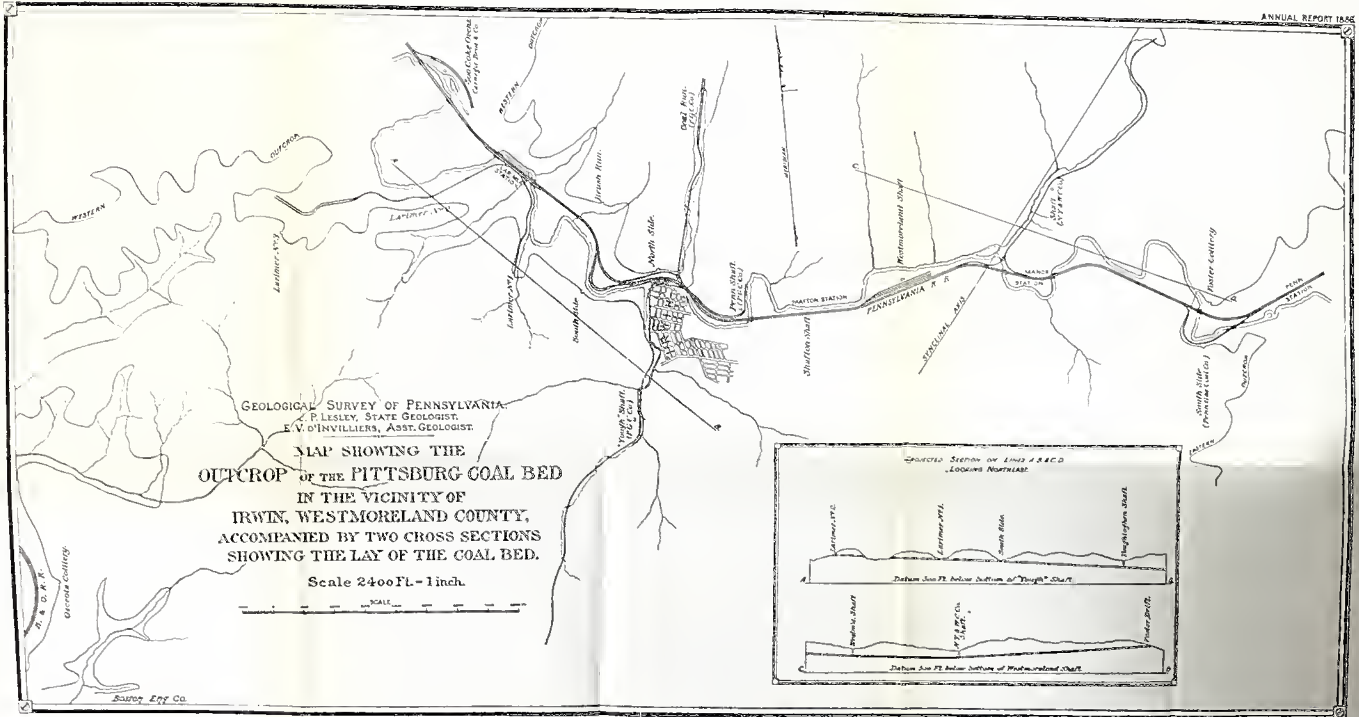
2. Where the elevation of the entrance to the mine is from—say fifty to several hundreds of feet higher than the tipple, and the coal is lowered down an inclined plane.

3. Where the coal lies at considerable depth beneath the level of the tipple, and is hoisted through a shaft or slope in the intervening strata.

Other things being equal, a colliery at which the coal is received from the mine at an elevation permitting its being dumped into cars for shipment without first being hoisted or lowered is one offering the best advantages for easy and economical operation; and if there be also sufficient height and ample dumping ground to expeditiously dispose of the dirt and slate sent out of the mine, operating expenses are always at a minimum.

For a shipment of one thousand tons *per diem* from a colliery of this class the employés required to transfer the coal from the wagons (mine cars) to the railroad cars are placed as follows:—

Two men to tipple or dump the wagons; one helper to start the wagons from the siding toward the "tipplers;"



GEOLOGICAL SURVEY OF PENNSYLVANIA.
J. P. LESLEY, STATE GEOLOGIST.
E. V. D'INVILLIERS, ASST. GEOLOGIST.

MAP SHOWING THE
OUTCROP OF THE PITTSBURG COAL BED
IN THE VICINITY OF
IRWIN, WESTMORELAND COUNTY,
ACCOMPANIED BY TWO CROSS SECTIONS
SHOWING THE LAY OF THE COAL BED.

Scale 2400 Ft. = 1 inch.

one wagon oiler; two car loaders; one car trimmer, to neatly arrange the lumps of coal on the tops of the cars, and one stout able boy to run the cars under the tipple from the tail tracks. But where the grade is too light for the cars to move by gravitation, two mules are added to the force to haul the cars from place to place. And according to the quantity of slate and dirt sent out of the mine one or two men and a mule are required to remove and unload it.

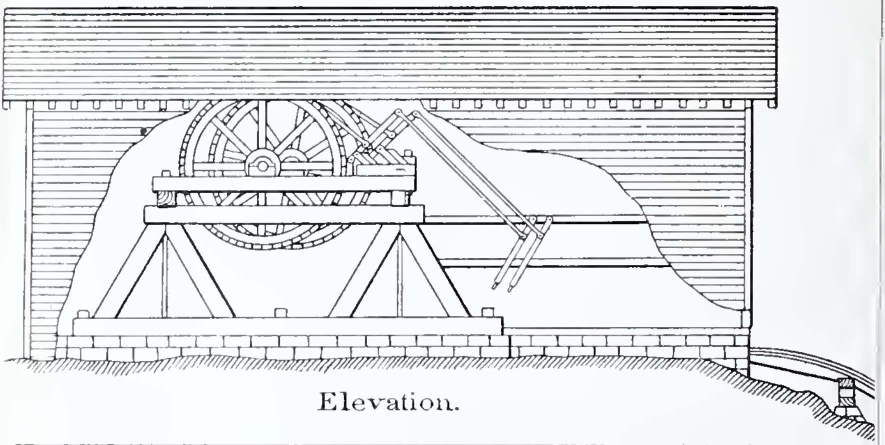
The above disposition of the operatives applies to a tipple having a revolving screen, where the height is 25 feet between the rails on the tipple and those on the tracks under it. Where the height is less, and until it is reduced to 21¼ feet (which is the least height admissable) a boy is employed to push the slack with a scraper down the schute into the car under the screen. The screen used should be 10 feet long, 3 feet in diameter, and the segments half inch mesh. A screen mesh of this kind removes all less than the Anthracite coal size known as "pea."

At collieries where revolving screens have not yet been introduced, at least one boy is kept constantly employed raking nut coal from between the lower bars, where it becomes wedged in the interstices and prevents the slack from passing through. And where the height of tipple is only twenty-one and one quarter feet, three large, strong boys are kept busy, for the height is not enough to give the schute sufficient pitch to carry the slack from beneath the second and lower set of bars to a car on a parallel track; hence the slack drops through into a car immediately under the bars, while the nut passes over, fills a "dumper," and is then conveyed by the boys fifty feet or more to a car in front of and on the same track as the slack car.

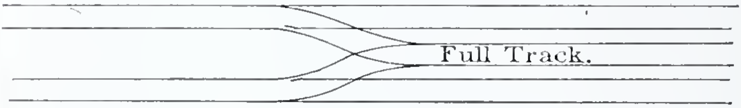
There is much difference between the nut coal from a revolving screen and that screened over bars, the former being perfectly free from slack, while the latter is sometimes half slack. The difference too between the quantities of nut and slack gotten by each method of screening is also a matter of some importance, as the following figures show:—

INCLINED PLANE.

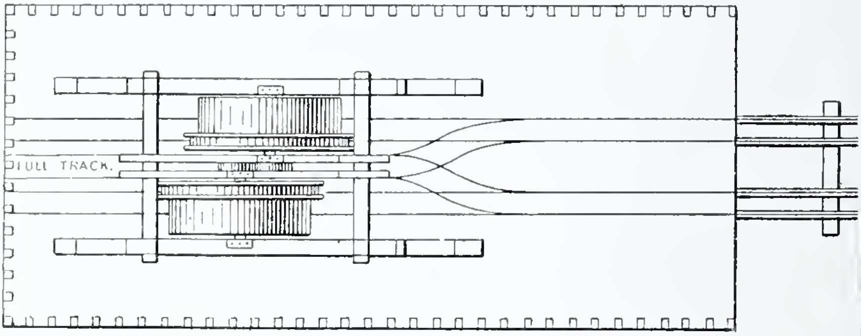
TRACKS AND MACHINERY.



Elevation.



Tracks at foot of plane.



Plan.

GEOLOGICAL SURVEY OF PENNSYLVANIA.
J. P. LESLEY, STATE GEOLOGIST.
E. V. D'INVILLIERS, ASST. GEOLOGIST.

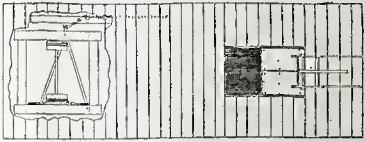
Larimer Tipple

OF THE

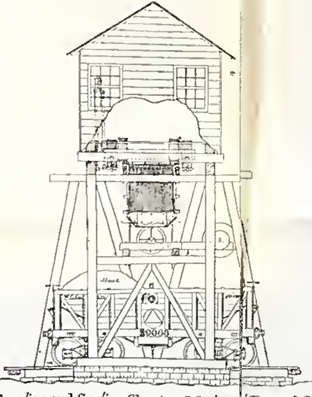
WESTMORELAND COAL COMPANY.

By A. N. Humphreys,
ENGINEER WESTMORELAND COAL CO.

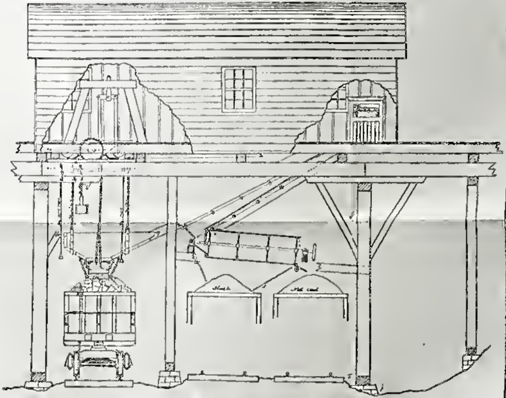
SCALE ½ INCH TO ONE FOOT.



Plan of Top of Tipple Showing Scales Connection.



End Elevation and Section Showing Schutes at Rear of Screen.



Side Elevation and Section through Centre of Screen.

	OVER BARS.		SCREEN, ½″ MESH.		SCREEN, ⅜″ MESH.	
	Tons	*Per Cent.*	*Tons*	*Per Cent.*	*Tons*	*Per Cent.*
Lump,	1000	83	1000	83	1000	83
Nut,	75	6	106¼	8½	125	10
Slack,	137½	11	106¼	8½	87½	7
Total,	1212½	100	1212½	100	1212½	100

These several percentages are based upon one thousand tons of lump.

Here it will be observed how very important it is to locate the tipple where the height will be great enough to permit arranging the screening apparatus to work automatically. The accompanying drawing of Larimer tipple will illustrate this fully and demonstrate how less height would lessen the pitch of the schute under the screen and very quickly interrupt any intended decrease in height.

The method of weighing can also be readily understood by an examination of this drawing. It will be seen how the coal descends over the bars into the iron basket suspended by chains from the scales frame. After being weighed, one of the pawls is disengaged from the ratchet wheel on the drum above by a pull on one of the handles, hanging near, when the coal presses open the doors at the bottom of the basket and hoists up the counter-weight, which is prevented from falling back by the pawl on the opposite side of the ratchet wheel. After the coal has all left the basket, the doors remain open until a jerk on the other handle pulls out that pawl, when the weight drops and closes the doors; and so on.

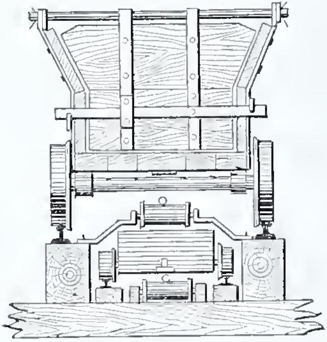
Inclined Planes.

Where the coal is lowered down an inclined plane with tracks and machinery as illustrated on page 418, three men must be added to the force previously enumerated. These three can handle fourteen hundred tons of coal in ten hours. Another man is placed at the foot of the plane to uncouple and transfer the rope from the full wagons to the empty ones. Three full wagons are lowered at a time, hauling up three empty ones.

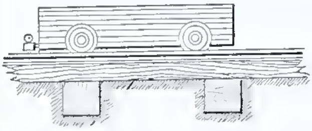
There is a descending grade toward the plane on top for full wagons and from it for empty ones, and from it at the foot for full wagons and toward it for empty ones.

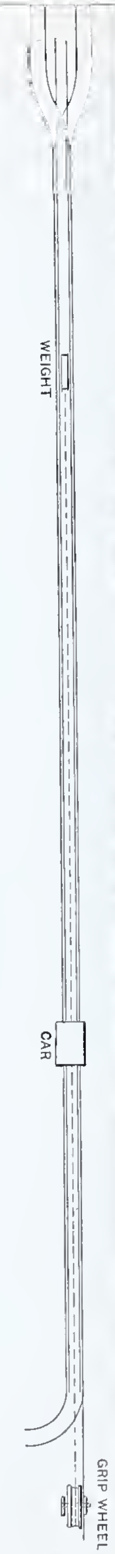
EQUIPMENT FOR SLOPE CARRYING SUPPLIES INTO THE MINE.
AT WESTMORELAND SHAFT COLLIERY.

CAR & WEIGHT



WEIGHT TRUCK





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With this plan there must be some standing room for wagons between the foot of the incline and tipple. This is necessary, as well to facilitate the shunting of slate as to hold the surplus coal when it is sent down the plane quicker than it can be tippled. The latter frequently occurs, because more coal can be run down the incline than can be properly screened on one tipple.

On some planes only one wagon is let down at a time, and it is tippled immediately at the foot of the incline without being detached from the rope, tipple and incline being connected. This does well enough where the plane is short or desired shipments not very large; but for work of much magnitude the longer the plane the greater should be the number of wagons lowered at a time. There are other planes with drums, tracks, braking bands and leverage all differing from these, but none on which coal can be handled at less expense.

Slopes, Shafts and Tunnels.

Slopes as known in other mining districts are unknown here—for if an opening were driven in the coal directly down the dip it would be considered a dip entry.

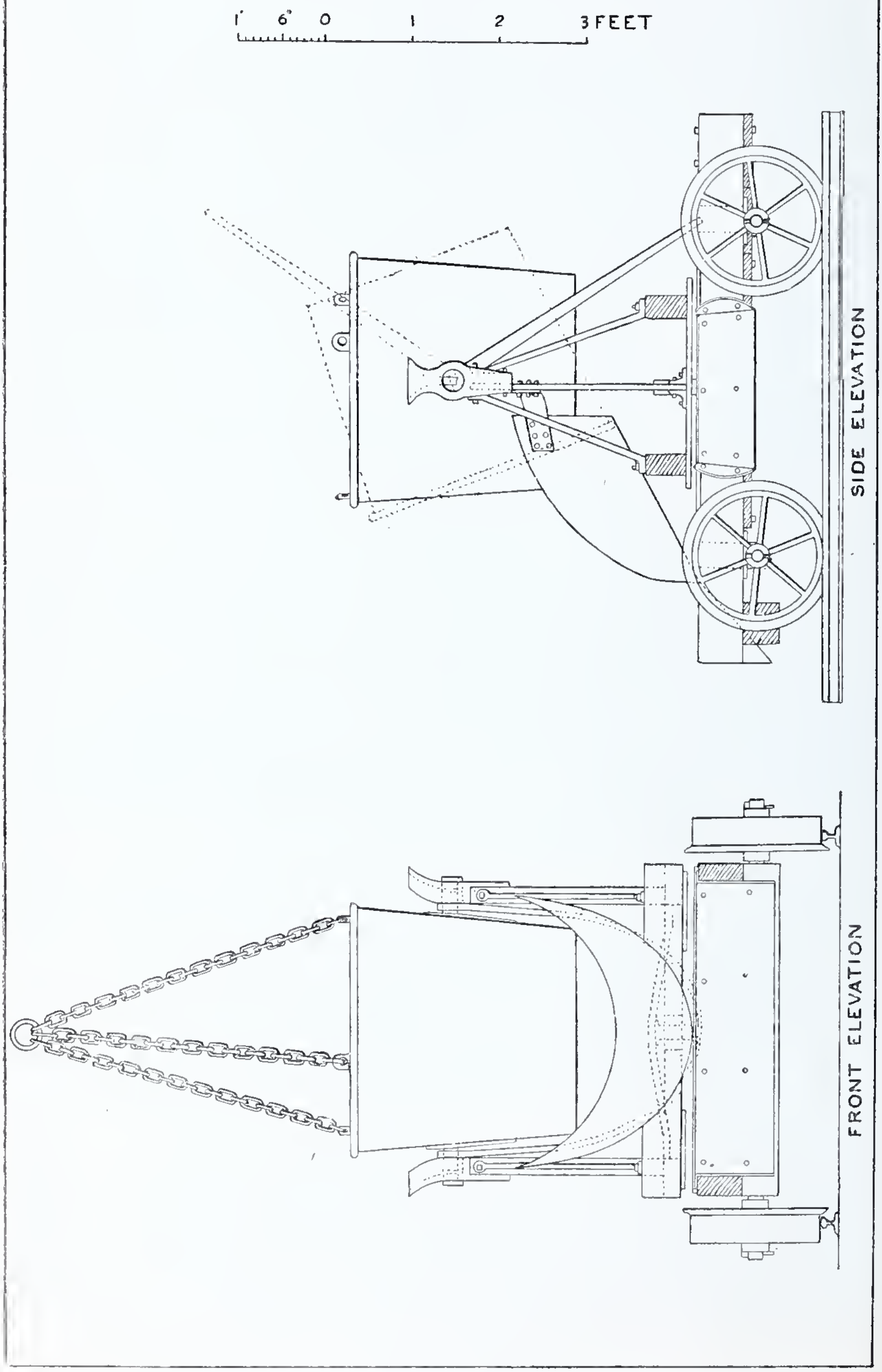
Our slopes then are of the kind known elsewhere as "rock slopes." They are sunk for traveling ways, for men and mules, diagonally through the measures at a dip of twenty degrees, or less, as called for in the "second opening clause" of the *mining law.*

Besides being convenient as an avenue of escape in case of threatened danger in the mine, they serve as an inlet for air, and as a means of getting timber into the mine without interfering with hoisting at the main shaft.

At Westmoreland Shaft colliery there is such a slope, with one track for lowering timber, and a traveling way on one side of the track. All the timber is taken in through this slope.

The rope leading from the wagon passes around a grip wheel (with a brake attached) and is fastened to a counter weight on wheels which passes through, up and down, under the wagon, as shown in the drawing on page 420.

TRUCK AND BUCKET
FOR SHAFT SINKING



By this arrangement the slope can be much narrower than would otherwise be possible, which reduces the expense of sinking. These slopes are simply "second openings" and are not brought into requisition for coal hoisting, though it would, perhaps, be wisdom to alter some of them for such a purpose since much more coal could be hoisted that way than can be gotten out in light small wagons, one at a time, through shallow shafts.

Our shafts are of four kinds, main, stair, air, and drain shafts; though some of them serve the double purpose of stair and air shafts, or drain and air shafts. The ordinary hoisting shaft is twenty feet long by nine feet wide, inside dimensions, having three compartments, two for hoisting and one for pumping and return airway to an exhaust fan. Eight inch timber is used and two inch planking.

The shaft sinking is generally done by contract, the price per yard varying according to the size of the shaft, costing more for the mining and removal of a cubic yard of rock or shale from a small shaft than for the same quantity from a large shaft. There is one air shaft twelve by thirteen feet at present being sunk, and now nearly completed, which is costing $2.12 per cubic yard, no timbering, but contractors finding powder, oil and tools. This is a much lower price than has ever been asked for any similar piece of contract work done here. As the contractors are doing reasonably well it may be assumed that this establishes a basis for all work of the same kind in future, providing day's wages remain about the same.

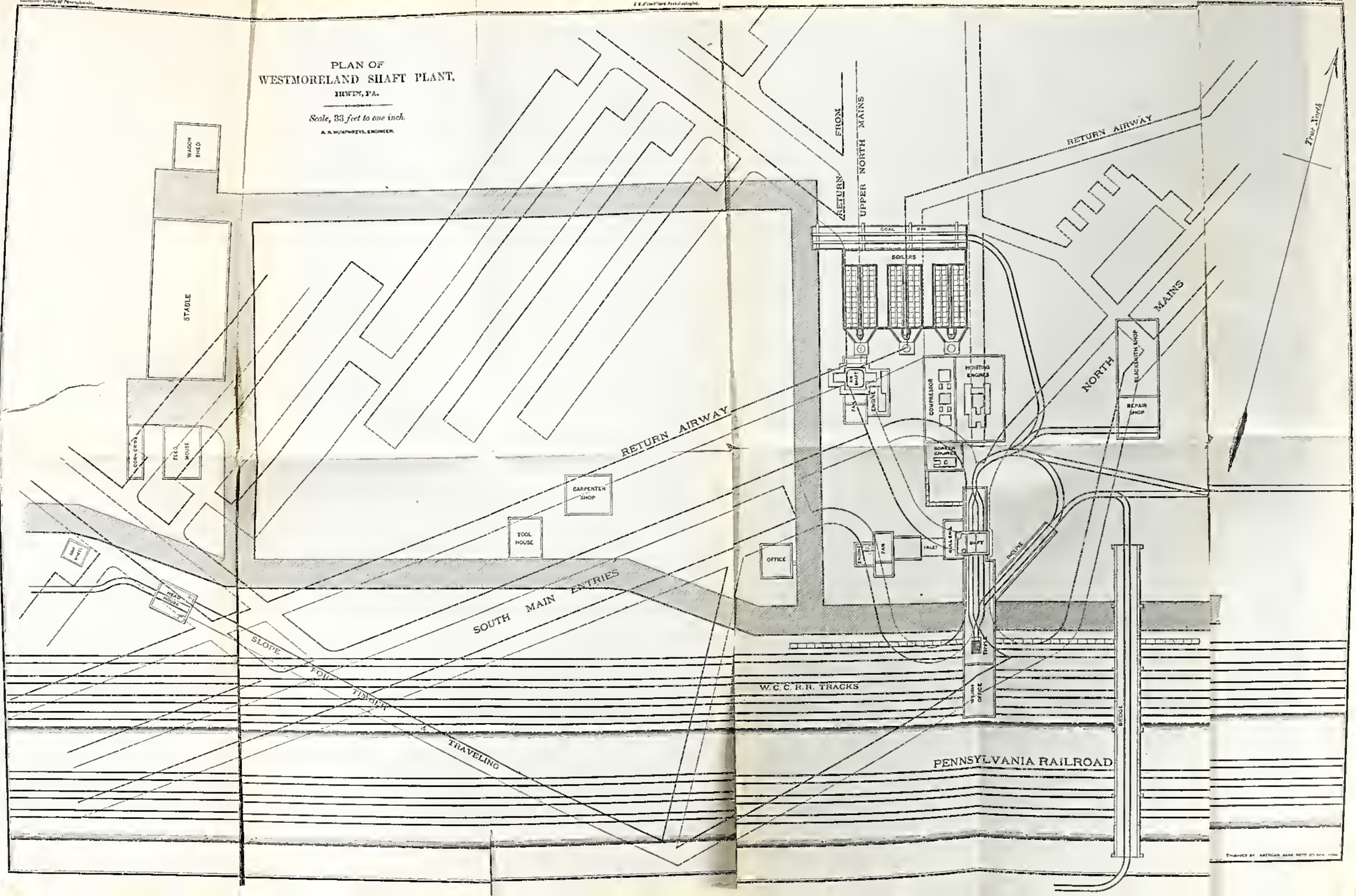
The machinery provided for sinking is of the very best description to facilitate the progress of the work. A simple contrivance for the removal of rock, &c., sent out of the shaft is shown on page 422.

Two buckets are lowered into the shaft, where one is filled and hoisted. The truck is then run under and the bucket let down upon it, the two lugs rivetted, one to each side of the bucket, resting in slotted receivers keyed to short shafts fitted in regular pedestals on vertical posts, which are securely fixed to a turn-table, fastened to the truck frame by a pin, upon which it turns. When in place upon the truck the bucket can be hauled away, dumped over the front end or either side as desired, and returned to the shaft. When coupled to the rope and lifted off, the truck is run from under until the bucket is let down and the other one hoisted. The under side of the truck frame is planked so that any pieces of stone shaken off an overfilled bucket when being placed on the truck cannot fall down the shaft and injure those employed below. While drilling and not hoisting, the "sinkers" prefer to have the truck standing over the opening at the top, as it prevents persons from falling or material from being accidentally thrown down the shaft.

Air shafts are sunk for ventilating purposes only, excepting where they can also be made available for pumping water out of the mine, or for stair shafts, which are traveling ways. Of course these shafts all vary in size more or less, according to requirements.

Exactly how much coal can be hoisted out of shafts we have not yet determined. From Westmoreland Shaft (a drawing of which is shown opposite,) two hundred feet deep, three wagons per minute or three and three quarter tons can be hoisted, which is at the rate of ten cars (225 tons) per hour, or twenty-two hundred and fifty (2250) tons per day of ten hours. This figure has not yet been reached. Dirt and slate must be hoisted, which delays hoisting of coal; besides the quantity exceeds the screening capacity of any one tipple. Fourteen to fifteen hundred tons of lump and nut coal is the limit of production at the best collieries in the district at present.

At this shaft, as will be seen by reference to plate, the main entry full roads through which the coal is hauled, start from the north side of the shaft and the full wagons are run upon the cages from that side. If not loaded with slate, when they reach the surface they are taken directly to the tipple and dumped, and when taken from there are shunted, fast end first, on to a siding leading to a short inclined plane, of easy ascent, up which they are moved by chain belting carrying attachments that catch the axles.



PLAN OF
WESTMORELAND SHAFT PLANT,

IRWIN, PA.

Scale, 33 feet to one inch.

A. H. HUMPHREYS, ENGINEER.

ENGRAVED BY AMERICAN BANK NOTE CO. NEW YORK

The slate and dirt is also taken up this plane and again side-tracked to be taken to the slate dump.

From the top of the plane the empty wagons descend around a curve to the shaft and are placed upon the cages, but reversed end for end. At the foot of the shaft they are bumped off the cages by full ones run on, and after passing around a curve to either the North or South Main empty roads are returned through them to the butt entries to be filled. Between leaving the cages and returning to them on the top or bottom of the shaft the wagons are reversed by the peculiar plan of the tracks and entries.

A pair of 20 × 36 inch first motion engines hoist the coal. As above mentioned they sometimes hoist three wagons (3¾ tons of screened coal) a minute from a depth of 200 feet.

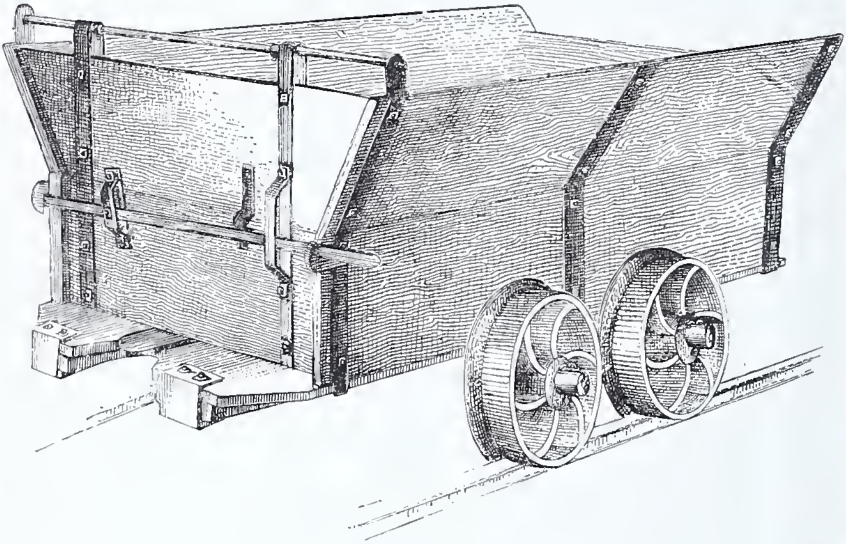
A bull engine with 50 × 120 inch cylinder and 20 inch plunger pump keeps the mine clear of water. This pump may be run as high as 8 strokes a minute without risk of being broken or damaged. The effective duty of the pump at 8 strokes is 1300 gallons a minute.

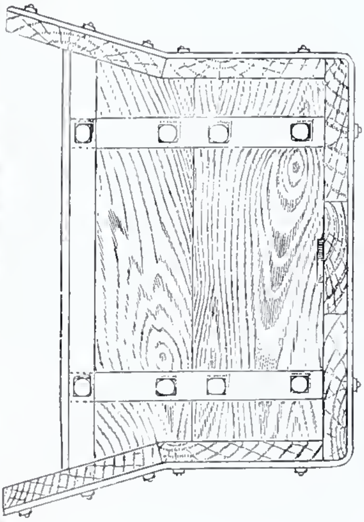
A pair of 8″×12″ engines provide the power necessary to run a fan for the blacksmith shop, to turn a revolving screen at the tipple, and run a lathe.

There are two fans at this colliery, and both can be used together or either alone. One is 12 feet in diameter, 4½ feet wide, with a 10″×12″ engine. This one exhausts air from the mine through a compartment in the hoisting shaft. The other is at an air shaft sunk to the intersection of three return airways, the mine being ventilated by three splits, and sometimes two, and other times three inlets. It is also an exhaust fan, built by this company. It is 24 ft. in diameter; 10 feet in width. The ventilating current produced by the latter varies as follows: at 30 revolutions, 75,000 cubic feet per minute; 60 revolutions, 130,0000; 75 revolutions, 167,000; the drag of current varies from $\frac{4}{10}$ to $2\frac{5}{10}$ inches of water.

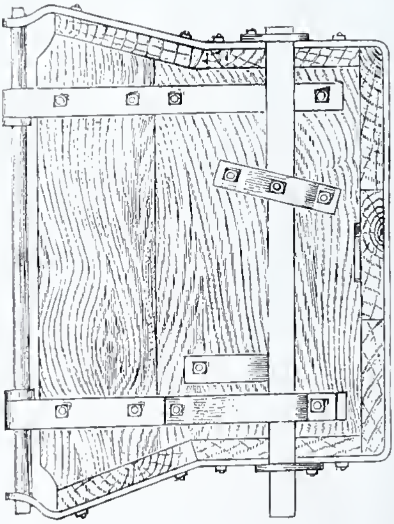
There are twelve boilers in the battery, in sets of two, so arranged that any two can be turned off from the main steam and water pipes at a moment's notice for cleaning or

DRAWING OF MINE CAR
USED IN PITTSBURGH REGION.





FAST END·OF CAR



OPEN END OF CAR

repairs. The supporting parts of these boilers rest upon rollers that they may move easily to allow for expansion and contraction. The feed pipe enters each boiler on top in the center of the middle sheet, passes downward to the bottom of the boiler, branches by a T to the front and rear, turns upward to near the "water line" and there delivers the feed water. The water is pumped into the boilers by donkey pumps.

Because of the lime and sediment in the water there are large mud drums under the boilers, one to each set, in which the accumulated dirt settles, and from whence it is cleaned out through "man holes" in the ends of the drums projecting through the side walls.

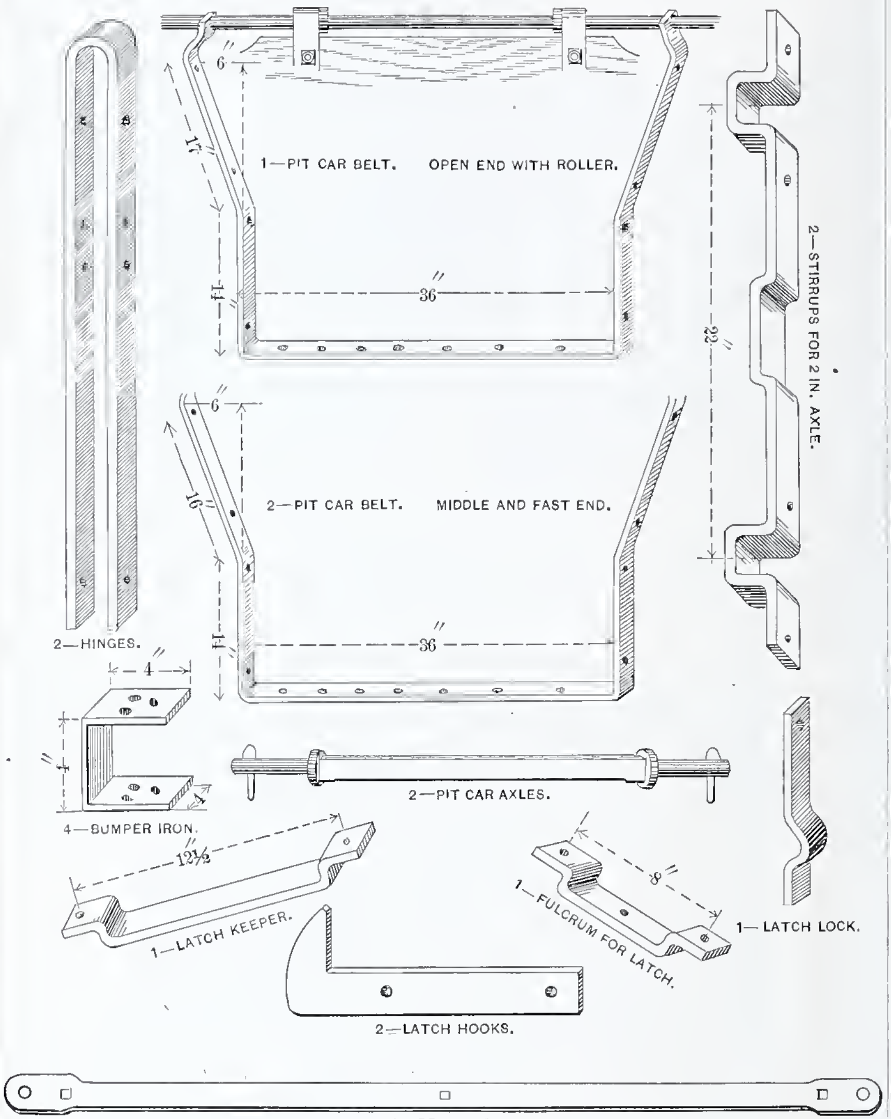
The fire boxes under the boilers are large; and as the flues, stacks, &c., were designed specially to create a draught of sufficient power to consume slack there is no trouble in generating steam.

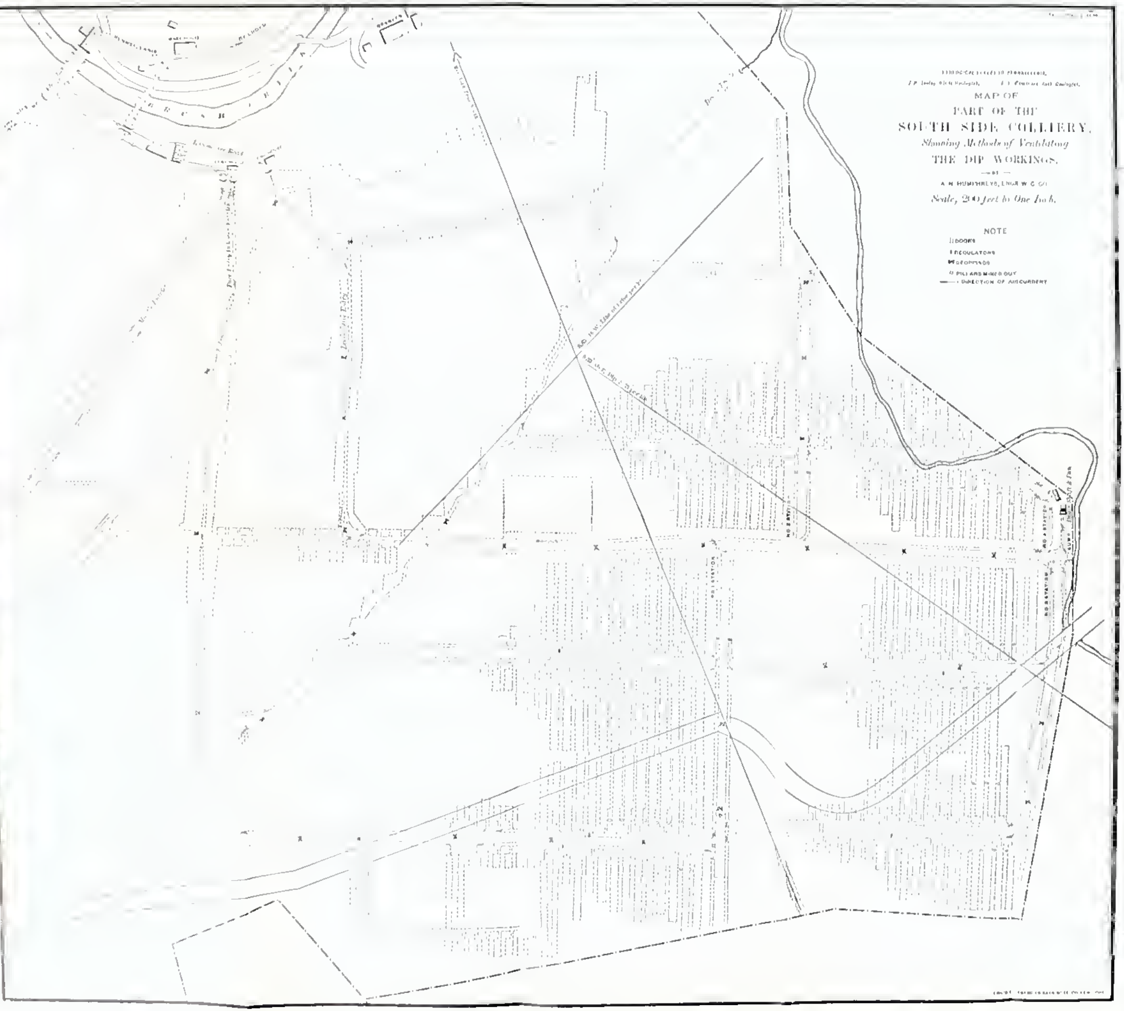
Tunnels are very few and located only at points where some local derangement occurs, where some minor axis elevates the coal above or depresses it below the line of drainage. And yet, from hearing workmen converse a person unacquainted with the mining terms in vogue with us would be led to suppose much tunnelling had been done here. The custom is to call a main or drain entry in the seam of coal a "tunnel," and more particularly so for some reason (which no one can explain) if the entry has been driven by set lines to reach a certain point or maintain drainage.

Underground Work.

In opening a mine it is necessary to know the position and direction of the minor axes in the vicinity, lest some expensive blunders be made. On the dip toward the southeast in this field into the main synclinal, there are local axes, (these little synclinals being called "swamps") which affect the drainage and haulage. In an unworked field where the seam crops out and can be entered by drifting, a good way to ascertain the precise localities occupied by these "swamps" is to sink proof holes along the crop lines

DETAILS OF PIT CAR IRONS.





[illegible]

J. P. Lesley, [illegible] Geologist, [illegible] Asst. Geologist.

MAP OF

PART OF THE

SOUTH SIDE COLLIERY,

Showing Methods of Ventilating

THE DIP WORKINGS,

— BY —

A. H. HUMPHREYS, ENG'R W. C. CO.

Scale, 200 feet to One Inch.

and take elevations of the seam at the different places. The workings can then be planned so as to have satisfactory grades for haulage and drainage.

All coal lying to the rise, or above the point of entrance to the mine, can be drained without pumping, and the coal hauled by mules until the distance becomes too great. Machinery is then substituted.

All coal to the dip or below the point of entrance, must be drained by pumping, if the water cannot find a lower level through some adjoining mine; but the coal must in any event be taken up hill, when mule haulage becomes too expensive.

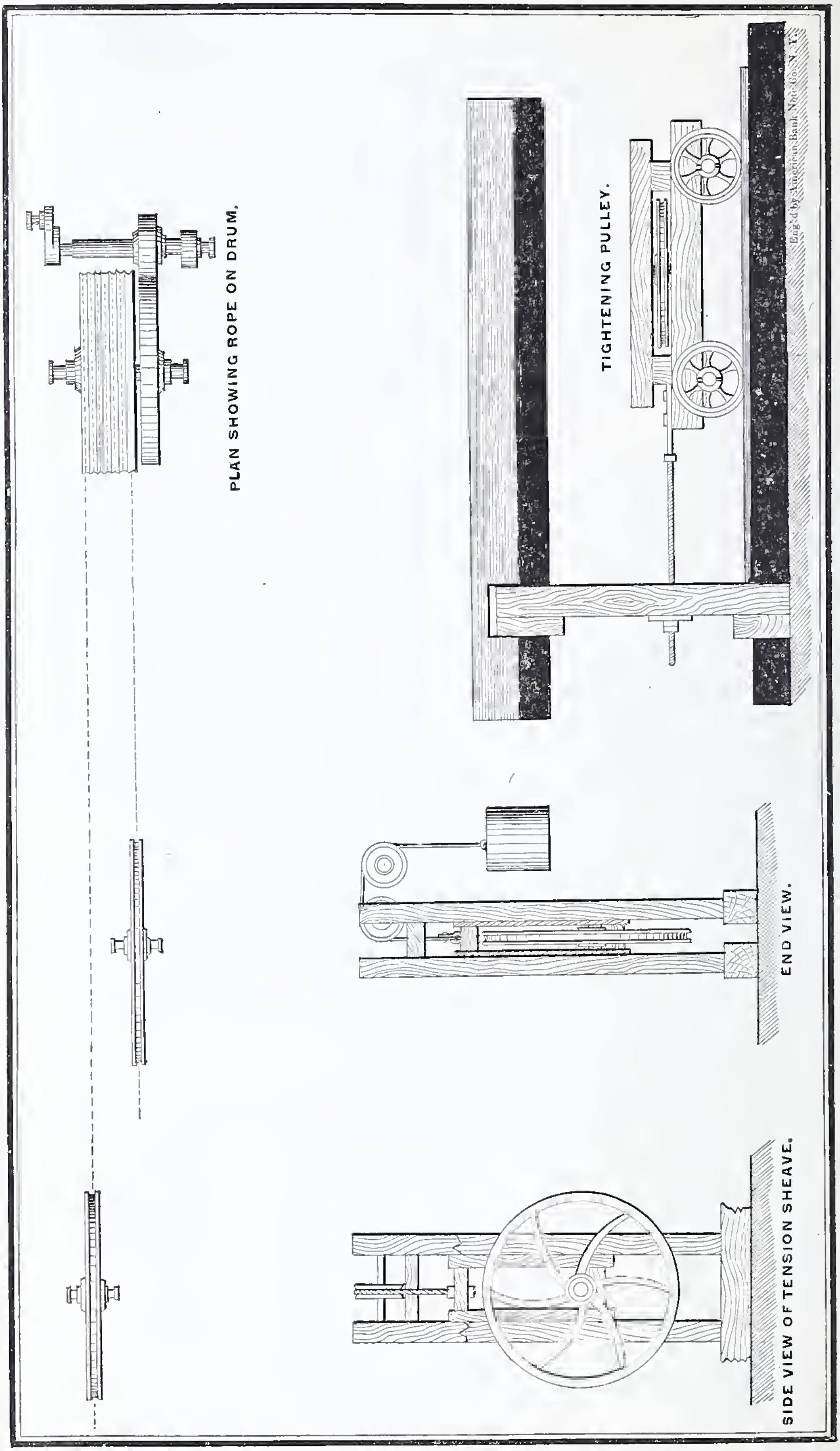
The mules at these collieries are sixteen hands (64 inches) high, and weigh about 1200 lbs.; but the very best mule can pull but two full wagons only a short distance up a grade of three per cent. At some places on the butt entries, the dip may be from four to five per cent. for several hundreds of feet, and to bring five full wagons down such an entry requires strength and skill on the part of the driver.

At the Westmoreland Coal Co's. South Side colliery, a mine locomotive hauls the coal from the dip workings. A plan of the method adopted for ventilating this part of the mine is shown in plate opposite.

There is a separate split of the air current for the locomotive road and none of the smoke ever enters where the miners work. The total quantity of air circulating through these workings is about 80,000 cubic feet per minute; 40,000 on the locomotive passage way and 20,000 in each of the two panels on either side of it.

The locomotive used weighs seven tons. The work performed by it is in excess of that of twenty mules. The distance traveled to make the round trip is nearly one and a half miles. Twelve to sixteen wagons are hauled at a time. Three hundred and eighty wagons (500 tons) and twenty-five or thirty wagons of slate, constitute a day's work; but five hundred wagons have been hauled in one day.

The steepest grade is 3 per cent. The expense per ton for hauling is $\frac{85}{100}$ of one cent. The expense per ton if this coal were hauled by mules would be ten cents per ton at the least.



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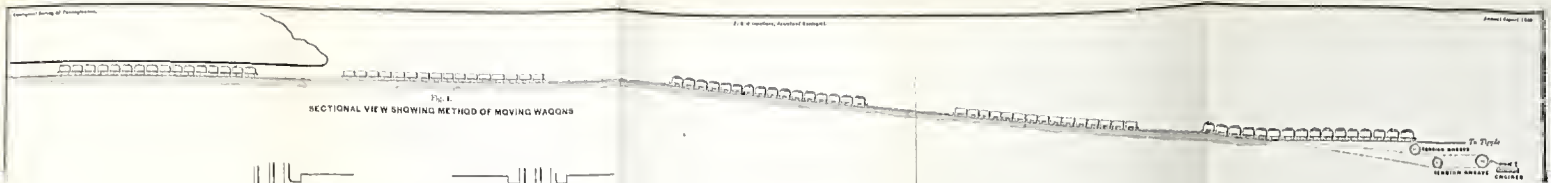


Fig. 1.

SECTIONAL VIEW SHOWING METHOD OF MOVING WAGONS

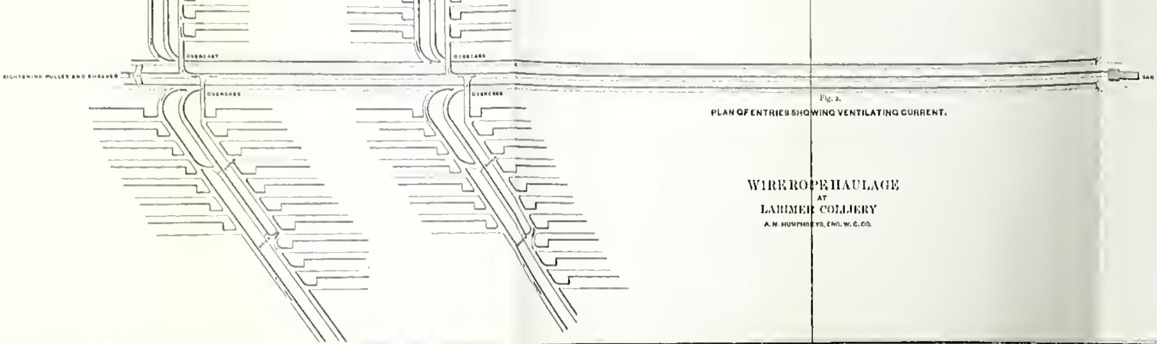


Fig. 2.

PLAN OF ENTRIES SHOWING VENTILATING CURRENT.

WIRE ROPE HAULAGE
AT
LARIMER COLLIERY

A. M. HUMPHREYS, ENG. W. C. CO.

[illegible]

At the Osceola colliery of the Westmoreland Coal Co., on the Youghiogheny river, J. H. Dewees, lessee, the tail-rope system on a small scale is brought into requisition for bringing coal up from the dip workings. The round trip distance is 2¼ miles. The daily shipment is three hundred tons; the expense of hauling being one and one eighth cents per ton. This is a cheap, inexpensive plant of machinery; but it does the work of nine mules. It is now about to be replaced by a plant of machinery with which the shipments will be doubled or trebled, as desired.

Wire Rope Haulage at Larimer Colliery.

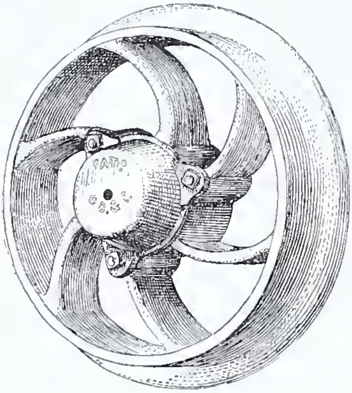
Plans for wire rope haulage to be shortly introduced at Larimer Colliery are presented in accompanying plates. It will be observed there are some new features introduced for the purpose of decreasing the number of employès required to transfer the coal from the mine to the tipple. The coal will first be hauled up grade out of the mine, (see Fig. 1) the rise being three feet per hundred, and then lowered down the hillside to the tipple, the grade being twelve feet per hundred, without uncoupling from the rope, which is economical to the extent of dispensing with the services of three men at the top of a gravity incline for lowering coal to the tipple.

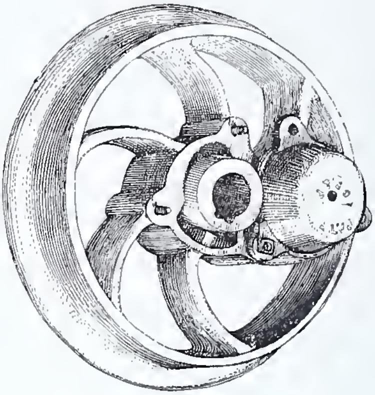
The wagons going down the plane outside assist the motive power applied in pulling the others up the entries to the "knuckle;" and the empties going up the plane are partly counter-balanced by those passing down the entry. This arrangement for hauling is somewhat like the endless rope system, but in this the rope is cut to regular lengths to reach between pairs of butt entries at regular distances apart, the several lengths of rope being connected by pieces of chain having swivels so the chain can be turned so that the links may be caught by clutches (see drawing) on the front and rear wagon of each train, the trains being coupled at both ends. To make the connection at a butt entry a mule driver will raise the chain up into the clutch, and slip the pin in under the chain where it will be kept by a catch, swinging on a smaller pin on the side of the clutch.

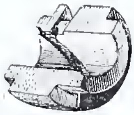
MINE CAR WHEELS.

"CHANNEL" OILING HUB WHEEL.

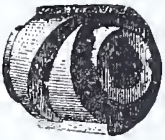
PATENTED SEPT. 2, 1884.



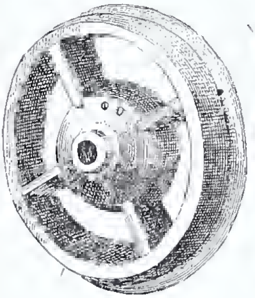


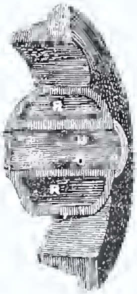


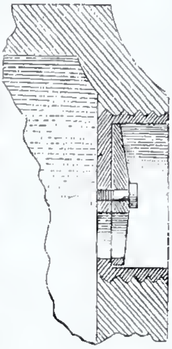
SECTION THROUGH HUB.



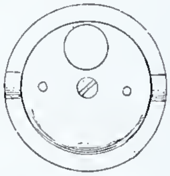
PART SECTION TO CHANNEL.

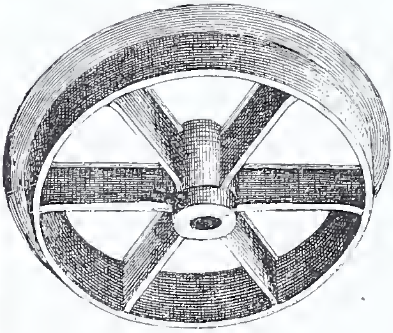




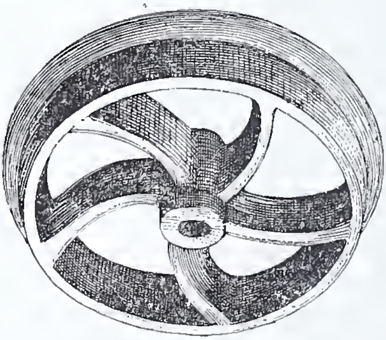


CUMMINGS & CO'S PATENT OILING HUB WHEEL.





COMPROMISE PIT CAR WHEEL.



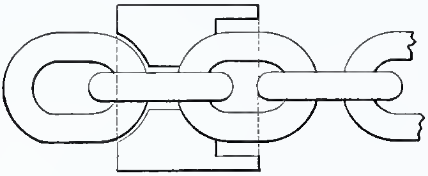
CHILLED PIT CAR WHEEL.

WIRE ROPE HAULAGE
AT
LARIMER COLLIERY.

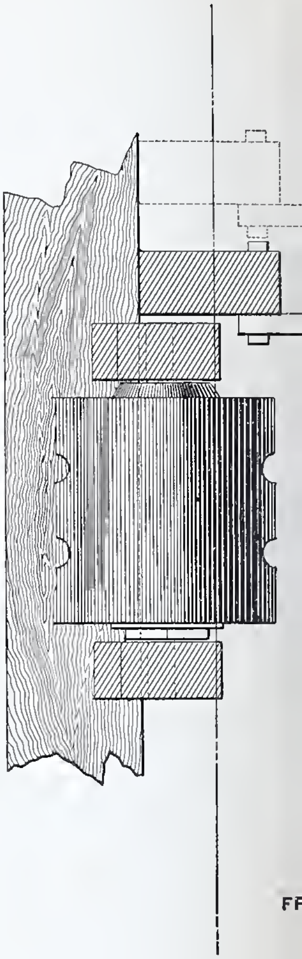
◆

DETAIL DRAWING
SHOWING
CLUTCH & CONNECTIONS.

A. N. Humphreys, Eng. W. C. Co.

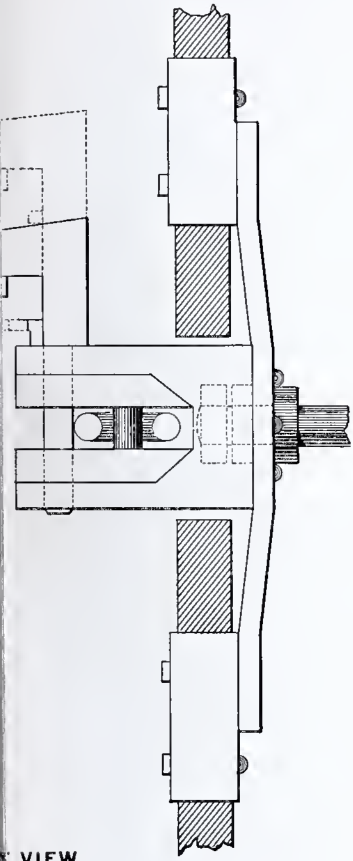


HORIZONTAL SECTION OF CLUTCH AT CHAIN

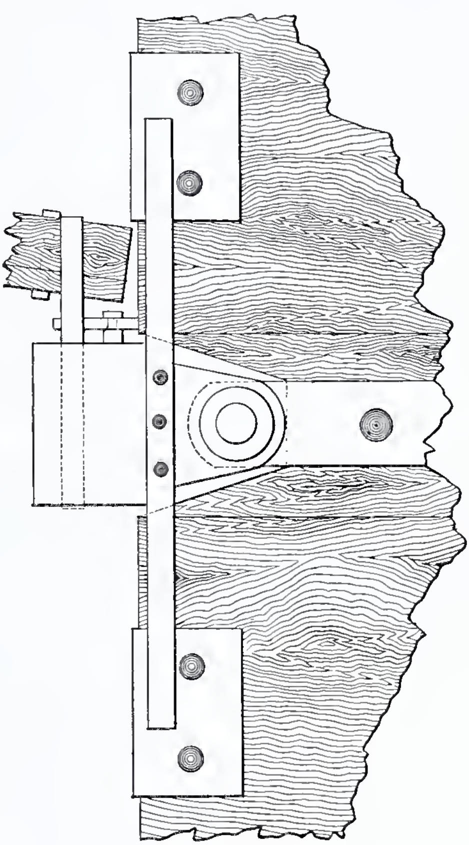


NOTE:
For other details of Wire-rope haulage at Larimer Colliery see page 430.

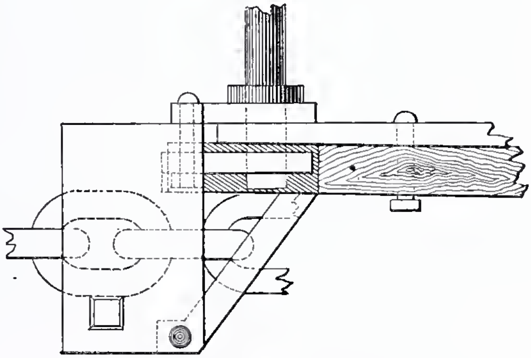
ENG.BY AMERICAN BANK NOTE CO.N.Y.



' VIEW



TOP VIEW



SIDE VIEW AND PART SECTION

The trains will be uncoupled from the rope automatically at the foot of the plane, which will be accomplished by bolting a piece of timber to the sills, the top of the timber being so high above them that one end of the "catch" is lifted up and the other end depressed which liberates the pin, the head of which is caught by an iron rod bolted on the timber and turned outward from the center of the track, which pulls the pin out and permits the chain to drop from the clutch and pass under the planking to the drums. The clutch is a strong steel casting fastened to a steel cross-bar that rests on the bumpers of the wagon, but reference to the drawings will clearly show its position when attached to the wagon.

A train will contain sixteen wagons, and four such trains will be on the rope at one time coming up an entry, while on the plane there can be but one, as one will be passing off at the foot when the next comes on at the top. While the full wagons will be coming up one entry the empties will be returning down the parallel. When the rope is stopped to couple the trains to it four sets of butt entries will be served at one time in either of the two main entries.

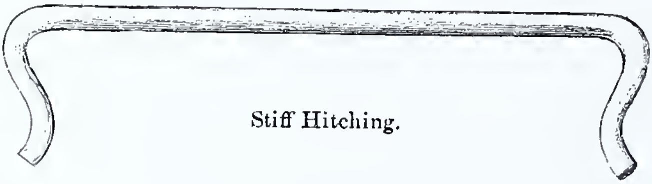
A one inch steel rope will be used ; and a pair of second motion engines, with $14'' + 24''$ cylinders, or their equivalent, will furnish the motive power.

To ventilate the workings one overcast and two doors will be required for each set of butt entries, as shown in the illustration, (Fig. 2.) The ventilating current will be produced by a "blowing fan," which is at present being used to ventilate adjacent workings.

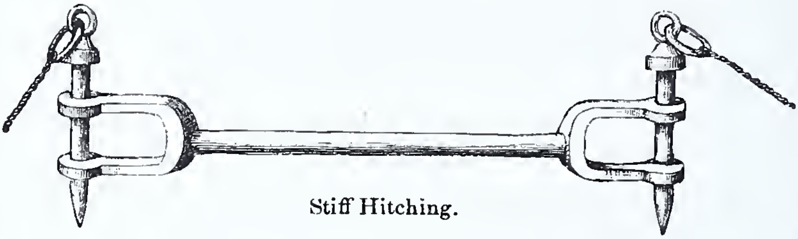
On one side butt entries will be driven from the main entries and the water will drain into the mains. On the other side this cannot be done, and the entries will be driven nearly quartering on the cleavage planes to facilitate drainage and haulage.

By this plant of machinery 2500 to 3000 tons of coal can be transported each day from the mine to the tipples, or more than can be screened at two tipples. The intention is to ultimately bring coal by it from a distance of nearly two miles.

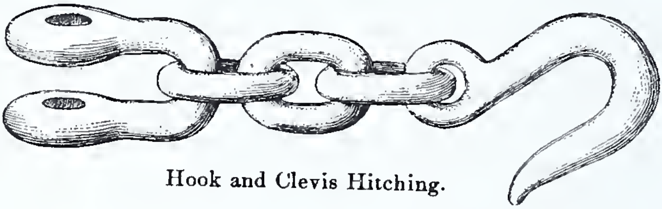
Mine Car Hitchings.



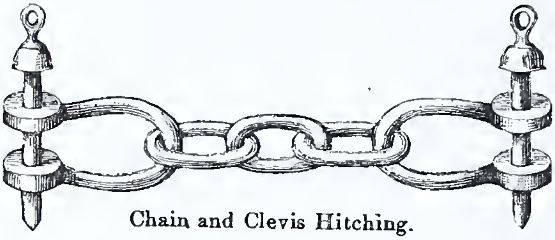
Stiff Hitching.



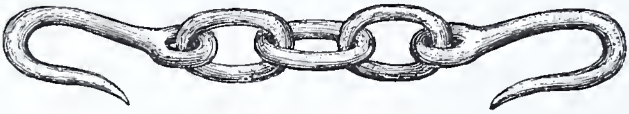
Stiff Hitching.



Hook and Clevis Hitching.



Chain and Clevis Hitching.



Chain Hitching.

Wagons—(Mine Cars.)

The wagons used in this district weigh ten hundred weight, and carry three times their weight of coal. They are built of plank, 2 inch bottoms, 1¾ inch sides and ends. The wheel base of wagons is 22 inches; inside length of body, 6 feet; inside width of narrow part, 2 feet 9 inches; height of narrow part, 1 foot; top width, 3 feet 10 inches; height of body, 2 feet 4 inches; total height above rail, 3 feet 5 inches. The gauge of track is forty inches.

The accompanying drawings, showing the wagons and details, are good representations. (See pages 426 and 428.)

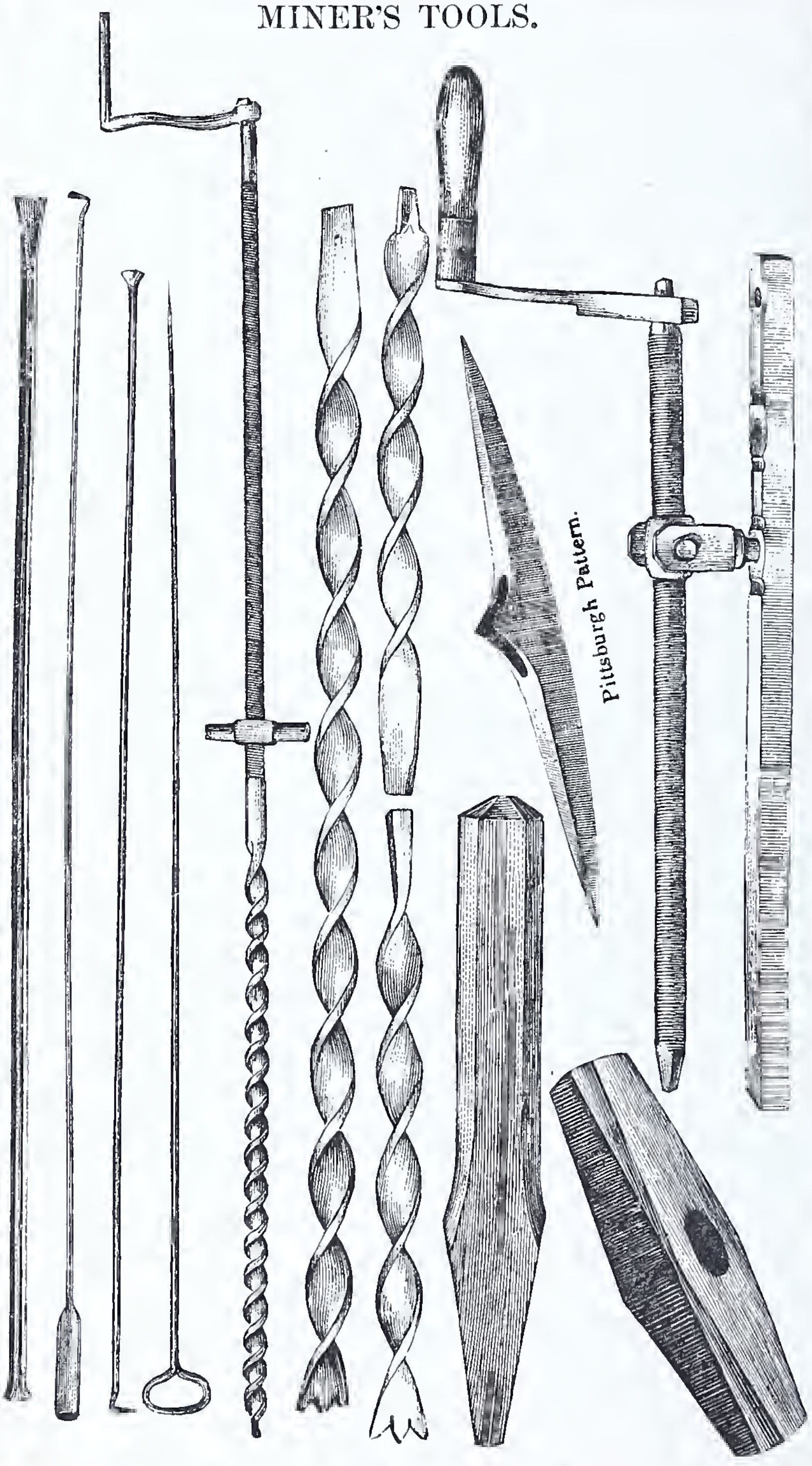
From the size of the wagons the statement of their capacity might seem incredible, but when full they are heavily "topped" with the largest cubes of coal.

The miners are instructed to endeavor to load as nearly as possible 2600 pounds of lump coal, and are paid to the nearest even hundred pounds above or below that. The average weight of lump coal per wagon is 1¼ tons, though some wagons contain 2800 pounds, and over, when well "topped."

With occasional repairs these wagons sustain about 8 years "wear and tear" in constant service.

When the haulage is lengthy, say from one to two miles, it becomes a matter of great importance to have wagons that run easy. Mules soon become disabled where the haulage is lengthy and the wagons are hard to pull, and for that reason almost any device to keep the wheels and bearings of axles lubricated is received with favor. The Cummings wheels, shown on page 432, is preferred by some operators, while others think the Channel oiler the better of the two. Operators all favor the chilled wheel. With a steel rail and old style of wheel a groove was soon worn into the tread of the wheel and the wagon did not run easily around curves. A chilled wheel is hard on the rails, the tops of which are soon worn so smooth that when a trip of full wagons with the wheels spragged is brought down a steep butt entry, if the rail happens to be wet, not enough friction is generated to retard speed, and this makes it dan-

MINER'S TOOLS.


Pittsburgh Pattern.

gerous for the driver and mule. Occasionally a driver is hurt, but more frequently a mule is killed.

The curved spoke of a chilled wheel makes it difficult to withdraw the sprags while the wagons are in motion. Foundrymen say they cannot make a chilled wheel after the pattern of the old style "Compromise wheel," the straight spokes preventing shrinkage and cracking the wheels while cooling.

The various forms of "Hitchings" or couplings used for mine wagons are shown in on page 434.

Methods of Mining.

The method of mining pursued here is on the "Double entry" plan, a pair of entries being driven on the butt of the coal parallel to each other and twenty-five feet apart, the ventilating current of air passing up one, through cross cuts, between, and down the other.

Rooms are turned off at right angles to the entries, on the face of the coal.

The longitudinal cleavage planes are called "slips," and an entry parallel to these is called a "butt entry." The lateral cleavage planes are called "joints," and an entry parallel to those is called a "face entry."

The angle between the planes is always nearly ninety degrees, the exception being where they may be deflected a little in the vicinity of a clay vein.

The air is turned into the rooms by canvas regulators hung loosely across the entry, and it passes from one room to another through headings. Reference to the plan of South Side dip workings will make this clear.

The rooms are driven on the face of the coal. They are twenty-one feet wide and the pillars are twelve feet in width.

While at "bearing-in" (undercutting, holing, undermining) the miner takes a reclining position, almost lying upon one side and cuts a channel from two and half to three feet deep in the face of the coal, taking out that part marked "bearing-in" in the coal sections presented elsewhere in this paper.

Having continued the channel as far as desirable, he then proceeds to blast down or wedge out the coal above, and afterward to raise part of the bottom coal by wedging, the lowest part of the seam not being mined. The character of miner's tools in general use is shown on page 436.

Many miners do not use powder, never having had any experience in its use, but force the coal loose by wedging. In some of the mines they are not permitted to use powder.

For the powder to render effective service the miner must be able to "bear in" not less than three feet in depth and many of them cannot do that. As with laborers, mechanics and tradesmen, so with miners, they differ vastly in their individual capacity to perform work. One man will mine much more coal in an entry eight feet wide than another will in a room twenty-one feet in width. There are some who can mine and load but little over one wagon per day, and others who can send out from four to five wagons a day.

After the rooms have been driven to the point of limitation, the ribs are cut through and taken out coming back.

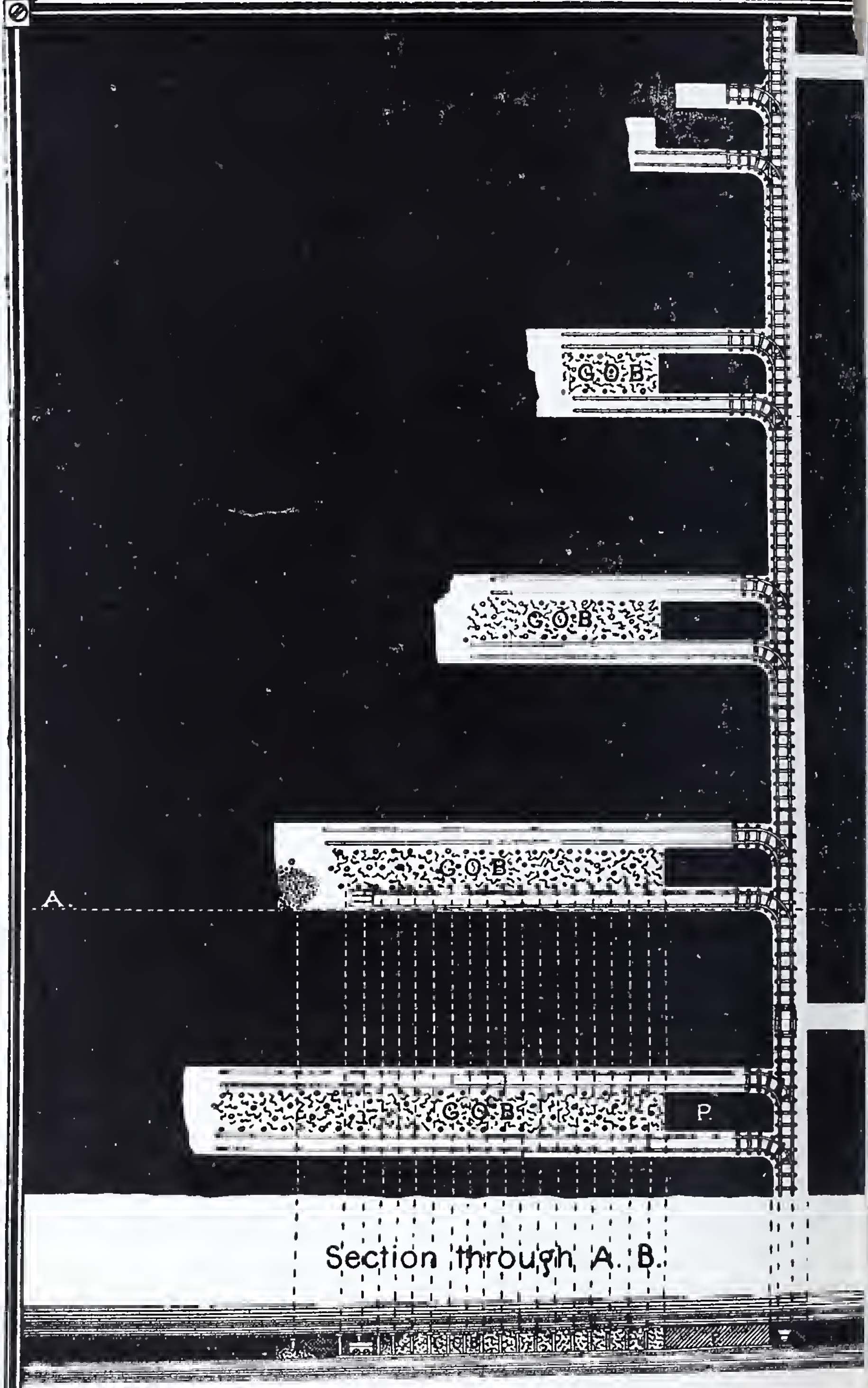
At the mines of the Penn Gas Coal Co. a new method of driving rooms and taking out ribs has been adopted, and that company's engineer, Mr. T. Frank Wolf, has kindly furnished the plan of their methods shown in accompanying plate. Mr. Wolf's description is as follows: "In the system shown by the accompanying plan, parallel entries about forty feet apart are driven on the butt of the coal, the rooms opening on the face of the coal. The distance from the mouth of one room to mouth of the next is sixty-nine feet; room being twenty-five feet leaving forty-four feet of rib, sufficient to prevent creeps under heavy covering. Two men drive a room and four men draw a rib; two working on each half, sending coal out by roads above and below.

Section through A. B. shows the room advancing; section through C. D. shows the rib drawing, taking the posts (props) out as rib is drawn back allowing the roof to fall."

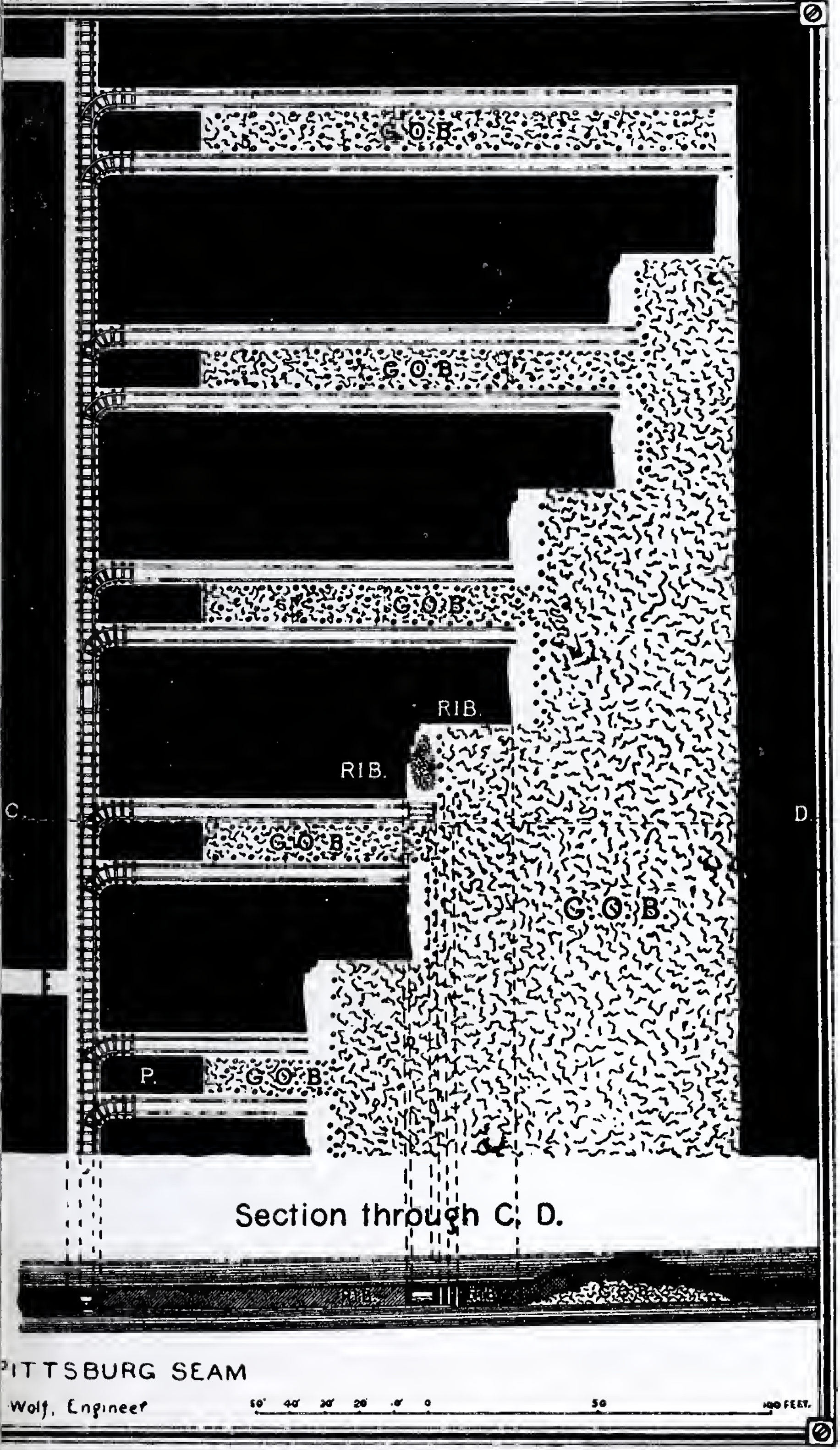
Mining Machines.

Harrison Mining Machines have been used at Westmoreland shaft for the last three years. The various patterns

GEOLOGICAL SURVEY OF PENNA. E.V. D'INVILLIERS



DOUBLE HEADING SYSTEM of WORKING ROOMS and RIBS in the
of COAL by the PENN GAS COAL COMPANY T Fran



ITTSBURG SEAM

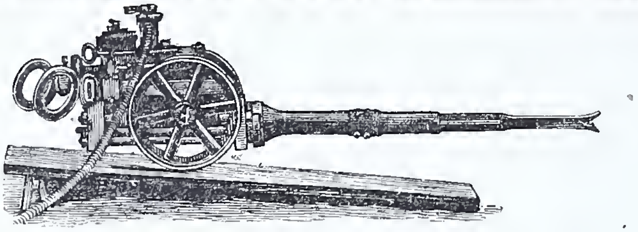
Wolf, Engineer

are shown on page 440. The size, simplicity, and strength of the machine are the pincipal points in its favor. Those who have seen the Ingersoll Rock Drill at work would at once understand the mechanical movement of this machine. The principal difference lies in the fact that the piston of the Ingersoll is rifled to give the drill, at its forward extremity, a rotary motion, and there is a ratchet and pawl attachment to keep the piston in place after each partial revolution; but the piston of the mining machine is square, runs in a square bushing, and cannot turn.

The pick at the end of the piston is forked to prevent glancing off when a thin slate parting is struck as it undoubtedly would with a single point. The machine cuts an open channel in or under the coal, as the case may be, of four and one half to five feet when bearing-in, and five feet in vertical height when shearing. As the bearing-in slack must be shoveled back in the gob, the machine wastes perhaps a trifle more coal than the miner.

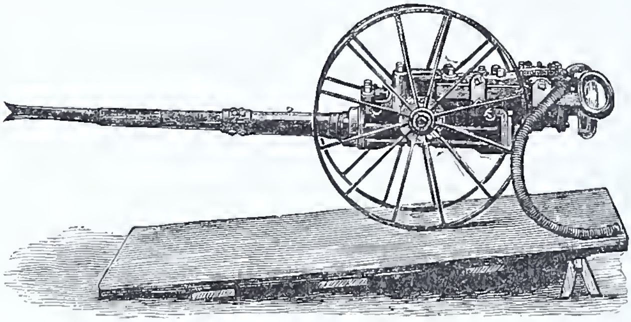
The machines are operated by contractors. There are three contractors (partners) to each machine, one of whom is skilled in running it. One of the others attends to "prop setting," blasting, and directing their laborers; and the other is kept busy taking down top slate, (the fire clay) raising bottom coal, and trimming up the corners of the rooms. The contractors employ three laborers who load the coal into the wagons. The laborers load on an average twelve wagons a day each, and occasionally as high as fifteen. Besides this force there is another laborer, called "scraper," whom the Company pays. After a time the "scraper" who is intelligent and careful becomes a "runner" and *contractor*.

The average days work for the "runner" is two hundred and forty-five square feet of "bearing-in;" but the best "runners" can, under favorable circumstances, do as much as two hundred and eighty-five square feet. This is equal to the width of three rooms undercut to a depth of between four and a half and five feet. The quantity of coal gotten for one cut across a room is twelve and one half tons after having been screened on the tipple over bars set three



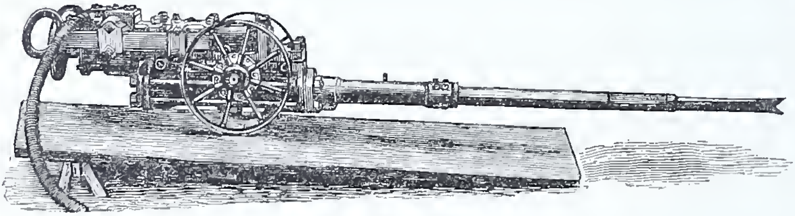
HEAVY STANDARD MACHINE.

Weight 700 pounds; mounted for mining; will bear under 4½ feet in depth.



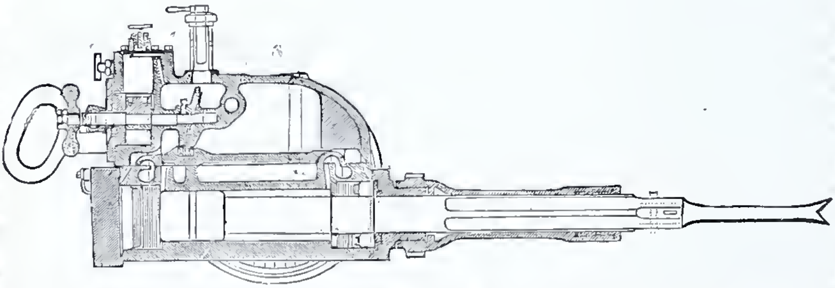
LIGHT STANDARD MACHINE.

Mounted for shearing; will shear 5 feet in height and 4½ feet in depth.



LIGHT STANDARD MACHINE.

Mounted for mining; weight 500 pounds; will bear under 5 feet deep.



LONGITUDINAL SECTIONAL VIEW, SHOWING SHORT HANDLES AND SHORT ROD.

quarters of an inch apart. The machines are also used for entry driving. Thirty tons is considered a day's work for each party of contractors. A cut, showing the appearance of the machine in operation, is shown on page 442.

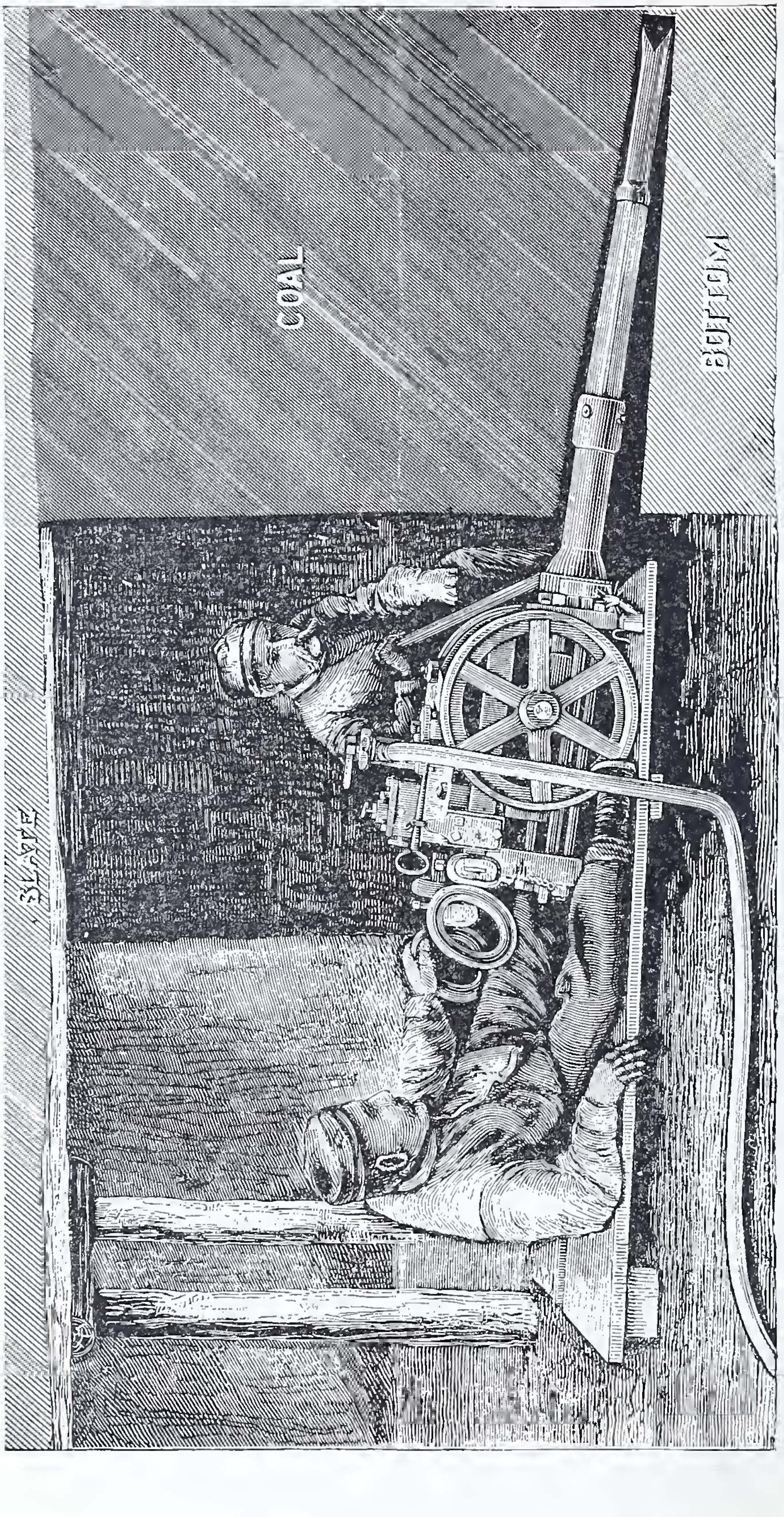
The bearing in is done as follows:

Beginning in one corner of a room, two small platforms are placed side by side, the ends furthest from the face of the coal resting upon two low trestles, so that the machine stands on a slightly descending grade toward the face, which causes it to follow up as the pick undercuts. When the runner desires to deflect the machine diagonally across the platform while working he swings it around in the proper direction and holds it in that position with a block strapped to one of his feet which he places behind one of the wheels. As the work progresses across the room the machine is moved from one platform to the other, the rear one with its trestle being always lifted and moved forward by the "scraper," while the "runner" keeps the machine uninterruptedly working. The "scraper's" principal duty is to keep the cuttings shoveled out of the channel in the face of the room and keep the lamps trimmed and placed so the "runner" can see just where to direct the point of the pick to deliver effective blows.

The machines are not mounted for shearing in this mine, powder being used instead to bring the coal down, though shearing by machine is preferable. After the bearing-in has been completed the entire width of the room, the machine is placed on a light truck and taken to an adjacent room.

A two inch hole, four to five feet deep, is then bored in each corner of the room, one of which is charged with about sixteen inches ($1\frac{1}{4}$ pounds) of powder. This, when exploded breaks the coal off at the rib and loosens it partway across the room. One third of the above quantity of powder is then put in the other hole, and with it the coal is brought down entirely. Three rooms are a set for each party of contractors.

Miners are now paid 55 cts. per ton for coal, and 80 cts. to $1.00 per lineal yard additional for entry driving. "Ma-



HARRISON COAL MINING DRILL IN OPERATION.

chine men" are paid 38 cts. for coal, and 45 cts. per yard for entry.

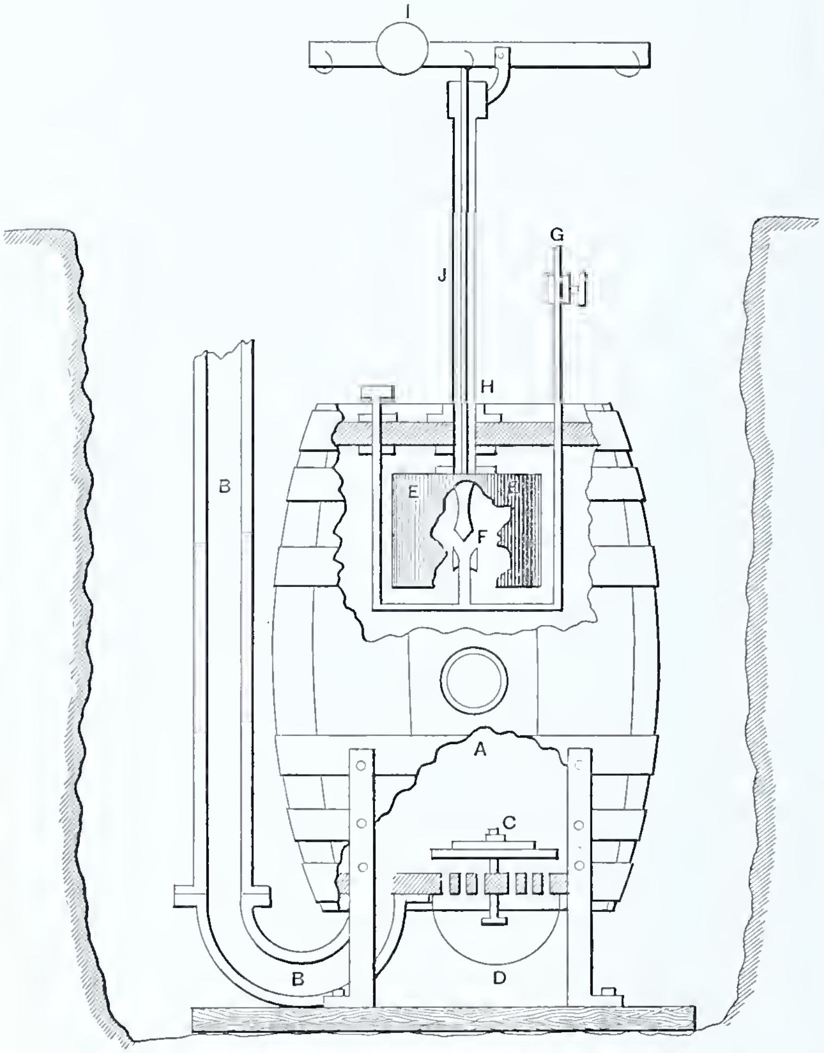
Twenty machines are in operation in this mine. A 26″×30″ Norwalk Compressor supplies sufficient motive power. To reduce friction it is good practice when putting in pipes to convey air to the machines to have them of ample diameter in main and butt entries to keep the velocity of the flow of air below 20 ft. per second. So far as the pipes in this mine have been tested we find when the air at the receiver outside is at sixty-five pounds pressure, the same pressure is maintained at the machines inside when they are not working, if the compressor be kept moving at the rate of fifteen strokes a minute. This shows that the loss for leakage is considerable. Not much of it, however, is through the pipe joints, most of it being through the hose connections and machines.

With the same pressure at the receiver and all the machines running the pressure at them is reduced to sixty pounds, which demonstrates that the frictional resistance to the velocity of the flow of air through the pipes is equal to five pounds per square inch of sectional area of the main pipe.

These air pipes leading through the entries and working places might be advantageously used if a serious mine fire should occur as they could be quickly connected to the column pipe of the Bull pump, and would then serve the purpose of an extensive conduit for water.

In addition to the mining machines, compressed air is used to run a lot of unique pumps in the shape of so many beer kegs, but better known as the *Wallace Automatic Water Elevator*. (See page. 444). At first sight one might consider them unworthy of attention ; but they are admirably adapted to the work they perform, *i. e.* elevating water out of rooms on the lower sides of entries, and keeping the water out of entries while crossing a "swamp," and until they are graded. We use the four and eight gallon keg sizes. They are set in small sumps into which the water drains, and fill and empty from four to six times a minute if the column pipe is not too long. A very import-

COMPRESSED AIR WATER ELEVATING DEVICE



SECTIONAL VIEW.

A—Main Cylinder.
B—Discharge Pipe.
C—Water Inlet Valve.
D—Strainer.
E—Buoyant Air Chamber.
F—Air Inlet.
G—Air Supply Pipe.
H—Exhaust Valve.
I—Regulator.
J—Exhaust Pipe.

Eng'd by American Bank Note Co. N.Y.

ant feature is, that they require no attention whatever, their action being automatic; neither do they require oiling or packing, nor stopping nor starting after being connected. The kegs work as follows:

The air introduced at air supply pipe G, is entirely shut off at the small air inlet F, by the weight of the regulator I and the chamber E E (which chamber is in form like an inverted bucket) while the water enters through the strainer D and water inlet valve C, until the main cylinder A is so filled with water as to cause the air chamber E E to become buoyant and rise, thus closing the exhaust valve H, and also opening air inlet valve at F. The air then enters the main cylinder A above the water, and with water inlet C and exhaust H closed the water is forced out of discharge pipe B B. The area of exhaust opening at H being much larger than the area of air inlet at F, the air pressure in main cylinder A is sufficient to hold up the air chamber E E, thus keeping the exhaust H closed, and air inlet F open, until all the water is forced out of the discharge pipe. As soon as all the water is discharged the air pressure in the main cylinder is at once reduced (by being fed by such a small air inlet and the weight of water gone from before it) so that it will no longer hold up the chamber E E, which at once drops, opening exhaust at H and closing air inlet at F, thus allowing main cyclinder A to refill with water.

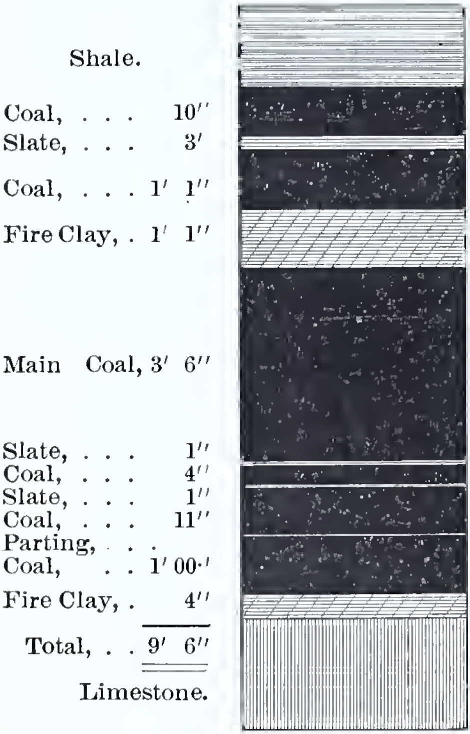
The regulator I can be placed on either side of the lever, so as to bear down or lift up the air chamber EE or taken off altogether, according to the air pressure used. When the vertical height is too great for the direct air pressure, the proportions are so arranged that one main cylinder of water will only fill in vertical feet of discharge pipe, twice the number of pounds of air pressure used, or less, *i. e.*, fifty pounds air pressure fills 100 vertical feet, or less, of discharge pipe; and as only one cylinder of water can ever be in the discharge pipe at a time, and the pressure is continuous until the water is discharged, the elevator can be made to lift water to any height, until overcome by friction, with no extra heavy pressure, heavy pipe, &c.

11. The Pittsburgh Coal.

The coal from this seam is so widely and favorably known, as coking, steam or gas coal, that its long established reputation precludes more than passing mention of it here. A typical section of this bed is here shown.

Variations from this section are local, and where they occur, the quality of the coal is not generally altered thereby. Where the largest clay vein cuts through the seam the coal on either side of it, after the fire clay is chipped off at the point of contact, is as good as could be desired ; and where a slack vein is discovered the coal on either side of it is actually harder than anywhere else, and more likely to generate carburetted hydrogen gas than at some undisturbed point.

Typical Section of Seam.



The appearance of the coal, however, is sometimes more against it than any real inferiority in its quality. Near the crop lines and where the rock is absent and shale above the seam thin, the coal may be slightly stained by oxidation ; and since the market will take little or none of this, thousands of acres of excellent coal are left in the mines of western Pennsylvania, probably never to be taken out.

The Pittsburgh coal is generally hard and bears transportation quite as well as the free burning anthracites. If properly mined, it comes out of the bed in cubical blocks, a large piece being an aggregation of smaller cubes, some of them microscopic, though the largest or smallest cube obtainable may be broken so as to show a conchoidal fracture.

The seam is divided by cleavage planes running at right angles to each other, which permit the coal being wedged out in cubes after being undermined.

The dip and trend differ at different places. At Larimer the average dip is 3 per cent. ; at South Side 2½ to 2¾ per cent. ; at Westmoreland shaft, 2 to 2¼ per cent. : showing a decrease from the west eastward, towards the synclinal line. The trend is subject to about the same alterations as the dip.

It seems quite probable that at one time the measures were either perfectly horizontal, or if they dipped slightly, that dip must have been uniform throughout. This is proven by the fact that if we follow the seam up or down the dip, say 3,000 feet, and it is for the whole distance 3 per cent, we will find if we go over the same distance with short measurements some places the dip flattening or reversed in "swamps," then it becomes much steeper, perhaps reaches 5 per cent, until the previous loss of elevation is compensated for, when it becomes normal, and may remain so for some distance.

Clay Veins and Slack Veins.

To those slight changes of dip must evidently be assigned the cause of the clay veins and slack veins existing in this seam of coal ; but so far I have found but one person who could give anything like an intelligent practical reason why they are found in coal seams. The general opinion of the miner is, "they begin somewhere, may extend anywhere, and end nowhere in particular, and no conclusions can be drawn as to what caused them."

Though widely different in character and composition it is probable that clay veins and slack veins should be classed together ; that they are of common origin ; that the cause which effected the one also produced the other ; that both are as old as the undulations that caused the flexures now observed in the strata. It would appear that after the previously plastic mass solidified and became coal an upheaval followed by partial subsidence must have occurred to cause these flexures. This not only broke and rent

FORMS OF CLAY VEINS IN BITUMINOUS COAL BEDS.

Fig. 1.

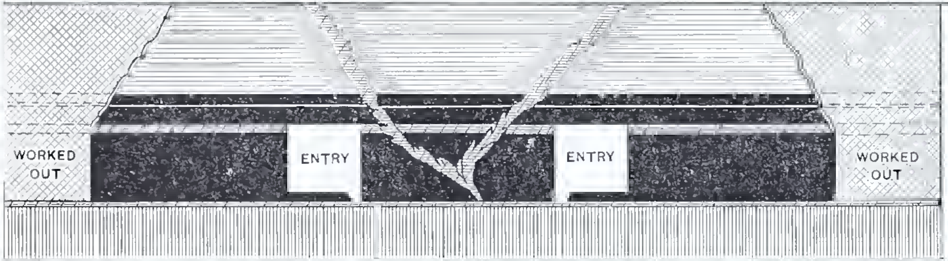


Fig. 2.

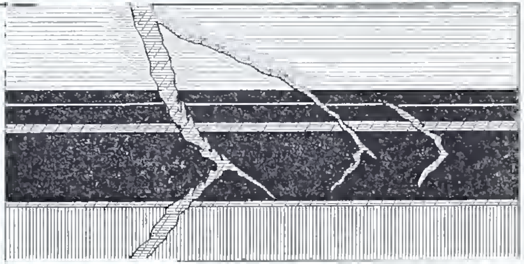


Fig. 3.

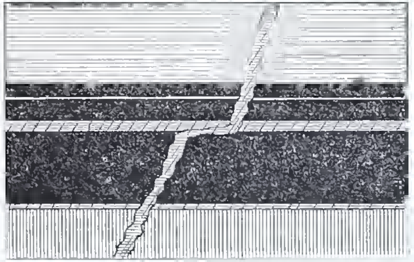


Fig. 4.

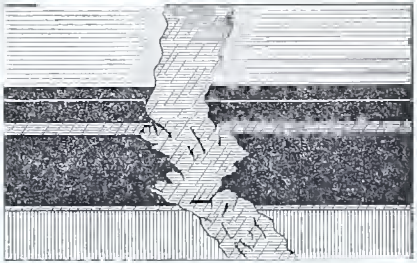
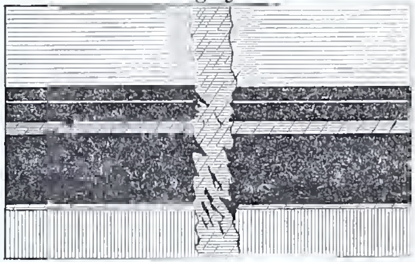


Fig. 5.



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assunder the seam of coal and enveloping strata in places, but also compressed and crushed them at other points where slack veins are seen.

Finally the rents became filled by clay infiltrations from the shales and fragments of sandstone in the overlying strata, and this material with pressure and the lapse of time hardened as the coal had before. Thus the clay veins were formed. They are the result of the tensile. and partly torsional strain upon the seam at the points where we find them. The sections herewith presented sustain this idea. (See page 448.)

Clay veins vary in thickness from six inches to six feet. A clay vein under six inches in thickness is called a "spar." Spars are branches from a regular clay vein as shown in section Fig. 2. Sections Figs. 3 and 4 clearly illustrate the breaking of the seam. The regularity of Fig. 5 appears to indicate a clean break and movement of the coal apart. This is the variety found in the strata hundreds of feet above and below the seam of coal much like a trap dyke.

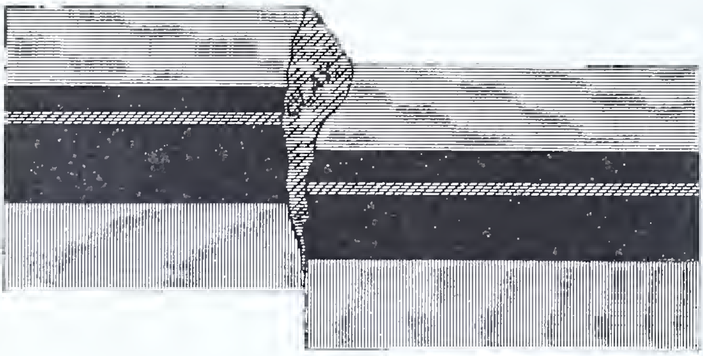
Fig. 1 shows the worst form of all so far as mining operations are concerned. Much coal is always lost along the line of one of these. Where one takes a zigzag course through the entry stumps, keeping nearly parallel with a pair of butt entries, if after the rooms are finished, the ribs are drawn back too close to the stumps and the roof broken on both sides, there is danger of the strata over the wedge-like or V-shaped piece being weighty enough to split the stumps, bring down the top and close the entries.

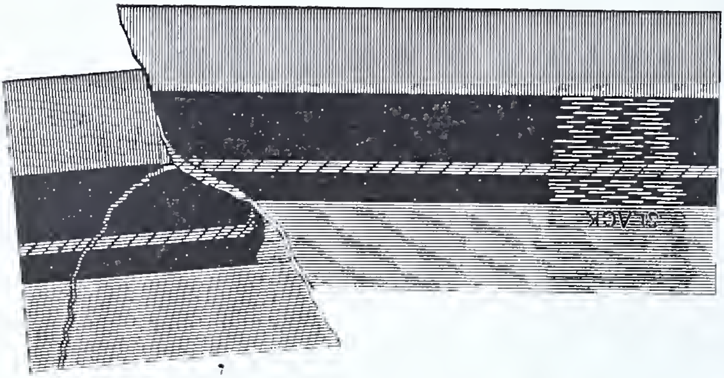
To formulate a theory by which a clay or slack vein could be ascertained far in advance of mining operations might reasonably be considered empirical; but that they can be approximately located for some distance in advance of entries as they are driven is certain in many cases; and the alterations of dip may be predicted from the clay or slack veins cut, with a reasonable degree of certainty.

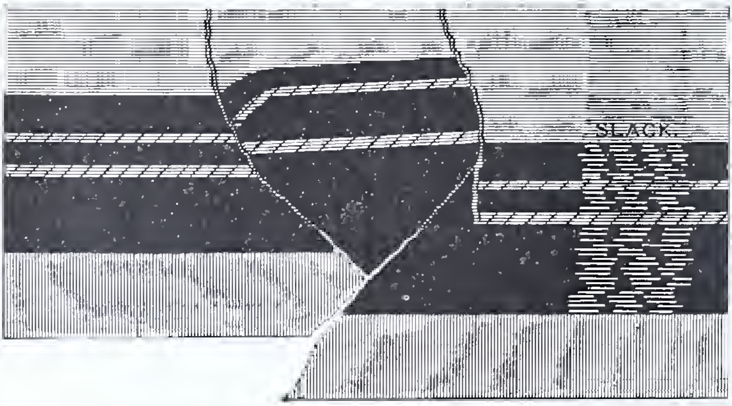
Clay veins are generally found on the tops of the declivities and on the dips toward swamps.

Slack veins are found in swamps or on a flat at the foot

FORMS OF FAULTS.







of a rise, excepting in such positions as shown in the forms of fault, where they exist under abnormal conditions.

The sections of the forms of faults (see pages 450, 452,) are shown here partly for the purpose of demonstrating that slack veins must have resulted from enormous compressive force. Indeed it seems they are still under some pressure, for in an entry driven through them the sides bulge and run in, and the top can hardly be kept up. Miners explain this by saying the gas forces the fine coal out; but the slack vein itself does not give off carburetted hydrogen gas. The phenomenon seems attributable to mechanical rather than chemical agency.

Faults.

Not more than one fault has been discovered in this basin, but this one is very persistent and extends from east to west, perhaps the length of the basin, through some of the collieries of the Westmoreland and Penn Gas Coal Companies. Some of the peculiar features acccompanying it (but not the fault itself,) were noted by Prof. Stevenson, and are mentioned in Vol. KK of the Geological Survey of Pa. It passes through the basin as shown in the sections of forms of fault. Generally it is seen as a couple of rolls in the roof extending down into and partly cutting out the seam, as in section Fig. 2. This dualistic form predominates; but at the points of transition to some other form the change is suddenly accomplished leaving no trace of resemblance to that form.

It is not so much the quantity of coal shattered or ground into slack along the line of fault which is to be regretted, as the changes of dip and other alterations found at some distance on either side of the fault. Sections illustrating these alterations are shown on page 454.

In Fig. 1 of sections near fault, a singular alteration is depicted. The streaks shown in the main coal are intended in some degree, to represent stones in the coal.

These stones lie in two different planes running parallel with the dip of the seam: the first from five to eight inches

THREE FORMS OF FAULTS IN BITUMINOUS COAL BEDS.

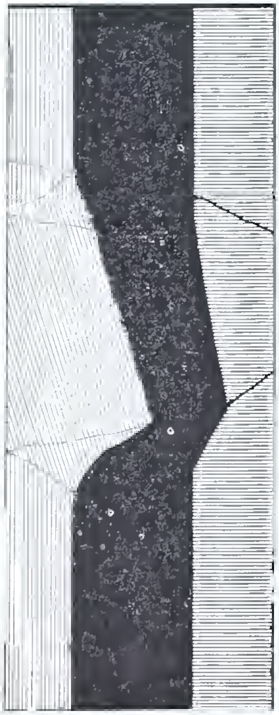


Fig.1

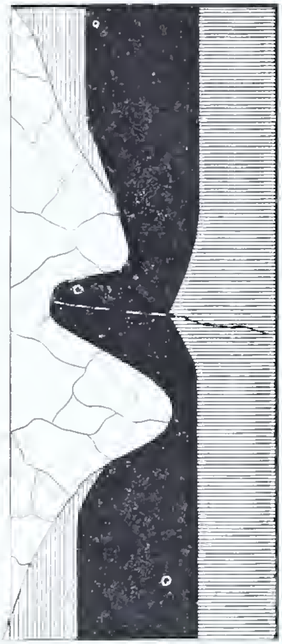


Fig.2

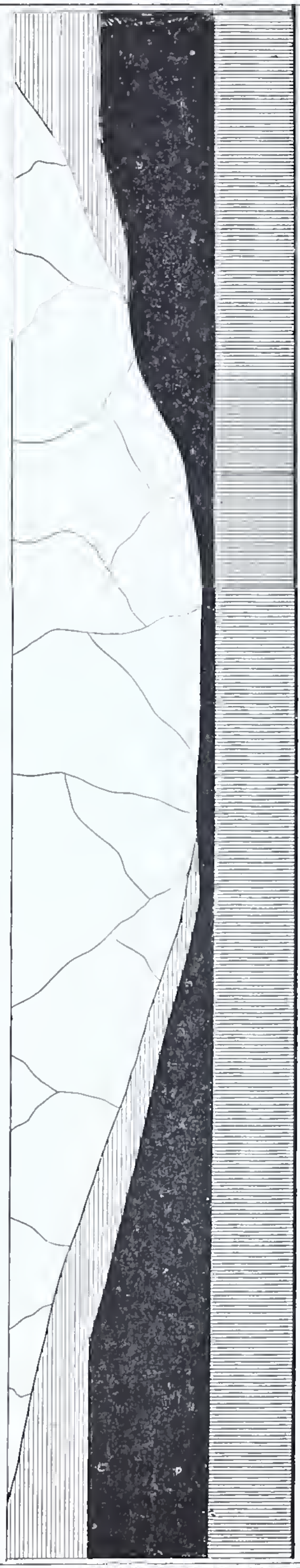


Fig.3

under the dividing slate; the second from twelve to eighteen inches above the "bearing in." A stone is very rarely found between these planes, and none above the upper nor below the lower. In the lower plane they vary in length and breadth from one foot in diameter to twenty; and in thickness from half an inch to three or four. Those in the upper plane vary between half a foot and four feet in diameter, and from one to eight inches in thickness. They cover many acres in area.

Of course no attempt has been made to mine this coal as it would be broken too fine to be marketable, and mining it would be too expensive.

In Fig. 2 of sections near fault it will be observed the fire clay that should appear in the seam is absent, and the sandstone which, when in its proper place, should be ten or twelve feet above the seam, with shale between, here becomes the roof. The coal is excellent. This point is much higher up the rise than where section Fig. 1 was taken; and as the stones in the seam there are of the same nature as the roof here it seems probable they came from this locality. But how they reached their present position in the coal down the dip is a difficult problem to solve.

Fire-damp.

Many persons who claim to be well informed on mining matters assert that carburetted hydrogen gas is never found above the line of water level (surface drainage). They are much mistaken. There are mines here in which large quantities of this gas is generated nearly a mile up the rise from the line of lowest drainage or water level.

In one of the Westmoreland Coal Company's mines where most of the workings have been above water level five "fire bosses" were until recently employed. At another colliery where operations are carried on at a depth of from two to three hundred feet, only three "fire bosses" are required. Curiously enough, too, at the former colliery 115,000 cubic feet of air per minute is circulated through the mine, and at the latter only 45,000.

As a rule, however, gas may always be expected to be-

COMPARATIVE SECTIONS OF PITTSBURGH COAL BED NEAR A FAULT.

Fig. 2

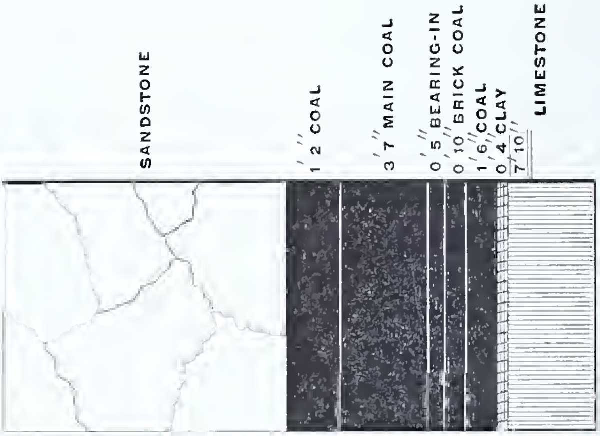
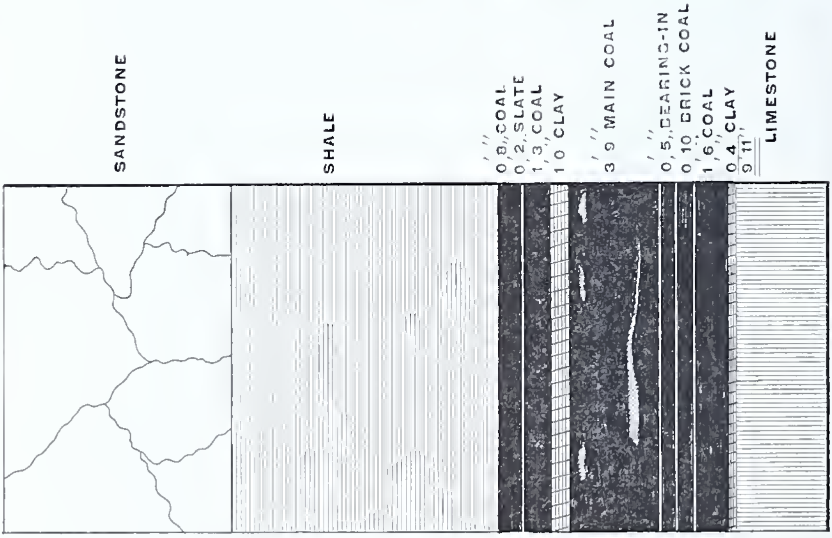


Fig. 1



come troublesome at the line of water level, where the coal descends below that line, though it may be found far up the rise above it.

In isolated patches of coal, where the crop line is all exposed, and the coal at no point descends below the line of water level, there is no probability of gas being found—though it may possibly exist even there, in an extensive patch.

Railroad Cars.

Having gone thus far in describing some of our mining methods and appliances this paper would be incomplete without referring, however briefly, to the cars that carry the product of the collieries, (half a million tons per annum,) to market. Many P. R. R. cars are used besides. The Westmoreland Coal Co.'s cars are of eight classes, viz :

DESIGNATION AND NUMBER.	Length.	Width.	Height from rail.	Capacity.	Light weight.
544 Dumps*	21′	8′	8′ 4″	30,000	17,000
118 Hopper gondolas	30′	8′	6′ 9″	40,000	19,200
7 " "	30′	8′	7′ 8″	50,000	19,700
50 " "	26′	8′	6′ 11″	40,000	18,300
140 " " . . .	26′	8′	7′ 11″	50,000	17,100
68 Long "	30′	8′	7 0″	40,000	18,700
215 " "	30′	8′	6′ 6″	30,000	18,000
58 Short "	26′	8′	7′ 3″	30,000	17,100
1200					

*Same as car on drawing of Larimer tipple.

The several capacities stated above are merely nominal in some cases, as for instance, where the capacity is said to be 50,000 lbs. and the car will carry but 48,000 lbs. Cars of this kind necessitate the expenditure of not a little money each year for car trimming. It would be well for car builders to discontinue the practice of building and stamping cars on this plan.

In conclusion I must acknowledge and express myself under obligation to our mining bosses and foremen for assistance; to Mr. A. Lock, in charge of the Company's car shops, for measurements, &c. promptly furnished; and to W. F. Caruthers, Esq., formerly Supt. for the Westmoreland Coal Co., and John McCallen for information concerning the early operations in and shipments of coal from this district.

On the character and distribution of Palæozoic plants.

By Leo Lesquereux.

To consider the march or evolution of the vegetation in different geological periods, one has generally to make up a list of species of vegetable remains, or rather of forms admitted as species, with the names of the localities where each of them has been found. At the same time references are made to geological sections showing the succession of the strata in the localities where the fossil remains have been obtained. In this way the different altitudes or horizons inhabited by successive groups of plants are exhibited; and lists of species may be made of all the plants pertaining, as far as known, to any fixed geological stage. It is in this way that the exposition of the Flora of the Carboniferous rocks in Pennsylvania and the United States (*) was prepared, and published in Vol. P^3 of the Second Geological Survey of that State; and there evidently the phytopalæontologist has at his command documents which may help him to follow the progress of vegetation through the whole thickness of the Coal measures of the United States.

Such a detailed exposition, with a long nomenclature, may be satisfactory to those acquainted with vegetable palæontology; but it does not afford, either pleasure or instruction to the general public, who, ignorant of fossil-botany, can not be interested in the names of beings of which they know nothing. For that reason and to follow the instructions of the Director of the Survey, I shall try now to give a clear idea of the general character of the plants of the Carboniferous, and of their successive modifications; not merely of those which properly belong to the Coal measures, but of those also which, found in older strata of the Palæozoic, may be considered as pertaining to the first land plants of the earth; in order to follow the march of vegetation,

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(*) Quoted C. F. in this article.

from the lowest strata where it has been observed to the end of the secondary period, the Permian.

It must be understood that this last remark strictly applies to land plants only. For, indeed, the preservation in a fossil state of the water plants, or Algæ (generally called Fucoids, *Thalassophytes*, when living in the sea; *Confervæ* or *Hydrophytes*, when inhabiting fresh water), is too rare to afford opportunities for studying them thoroughly; therefore no kind of evidence of the evolution of their characters during the Palæozoic times, can be presented.

Algæ.

The Algæ are plants either unicellular or composed of one or more layers of cells. In the first case, as mere separated cells, they are very small, perceivable only with the microscope; but by their connection, in rows of globose, oval or cylindrical cells, they become elongated and fill the water with their visible threadlike filaments. In the second case, they compose, by agglomeration of one or more layers of cells, cylindrical stems with round or flattened branchlets; leaflike plants, indefinitely varied in form and color; a vegetation of an admirable beauty, like that of prairies of flowers.

The Algæ grow in profusion not only fixed to the bottom by a kind of root, but expand and sprout at the surface of the sea into immense accumulations of vegetable matter thick enough to impede the progress of ships. Such are the Sargassum sea between Newfoundland and the Canary Islands, and the floating prairies of Fucoids between the Kuril Islands and Japan. And if a great many marine plants are too small to be observed without a lens, others attain very great size, becoming trees with large trunks, like those in a forest or grow to the prodigious length of 1500 to 2000 feet.

From this extraordinarily varied and sometimes mighty vegetation, it would be supposed, of course, that remains of Algæ should be plentifully found in a fossil state. But it is not the case. Marine plants, composed of mere cellular tissue, sometimes hardened by the action of the chemical elements of sea water, are destitute of woody fibre, that essential compound which can resist the rapid decomposition of the vegetable after death. Like the flesh of animals when exposed to the influence of the atmosphere, the cellular tissue is soon destroyed by the action of the oxygen. Therefore, marine plants, though heaped at the bottom of the sea, or embedded in sand, mud, or other material, rarely leave any remains of their tissue. If impressions of some kind are left, their outlines are generally effaced by the spreading around of the soft matter when subjected to compression. And even when the tissue is not totally destroyed, it becomes partly and irregularly absorbed, and nothing remains for the study of the plants but mere flakes of colored matter without definite forms.

This may partly explain the scarcity of fossil remains of Algæ ; and the difficulty of analyzing and determining them when found accumulated in abundance, as they are sometimes in beds of clay or sandstone. At first sight, a quantity of peculiar forms seem to be represented ; but the whole is like a mass of fragments, kneaded together so intimately, that even by long research the palæontologist fails to find among them any definite and persistent forms for specification. It is therefore not surprising to see such a great discrepancy between the number of fossil species of Algæ known or described by authors up to the present time, scarcely 150, and the number of those now living in the sea, of which more than 2000 have been described. It has been remarked above that marine vegetation is partly made up of thread-like thin filaments, composed of simple cells, connected each to each in various ways ; or even of simple cells of various forms which are not perceptible without the aid of the microscope. This kind of vegetation, on account of its simplicity of structure, may be called primitive. It must have been the first ; and it must have become prevalent in the oldest sedimentary rocks of the world, the Cambrian and Silurian.

No fossil remains considered vegetable have been recognized in the whole series of the Cambrian, except the *Old-*

hamia, an organism composed of extremely thin nodose filaments, either radiating all together from a central point, or attached in bunches to a flexuous geniculate stem. They are locally found in abundance; and are generally admitted to be the most ancient organism known; but their real nature is not yet positively ascertained. Some palæontologists take them for Bryozoans (moss animals) a peculiar kind of mollusca, while others, like the celebrated palæontologist Schimper, consider them plants. If Algæ, they clearly represent what the vegetation must have been in those ancient formations, when the water covering the primitive rocks, still heated to a high degree by the incandescent mass of matter under them, was of course near the boiling point, a temperature at which no highly organized beings could live. That kind of vegetation might be compared to that seen at our epoch in basins of thermal water—those of the Hot Springs of Arkansas, or the Yellowstone park, for example—which are filled with a peculiar kind of hydrophytes, green, long, simple, cellular filaments, as thin as spider threads, but forming large tufts by their agglomeration and active growth, though living in water constantly at the temperature of the boiling point. Passing upward into the Silurian strata, the marine vegetation is found to have been considerably modified; for the Fucoids described from this last formation by the great palæontologist Hall, are, some of them at least, of great size. Mostly cylindrical, simple, or ramose stems, sometimes articulate as in *Palæophycus* (*palæos* ancient *phucos* marine plant), *Harlania* (from its first discoverer Harlan) etc., they measure 0.2 in. to 1.2 in. in diameter or more.

Probably on account of the great difference of temperature of the basins wherein they lived, these primitive Algæ show a remarkable variability of size in the same species. This conclusion is authorized if we admit, for example, that all the plants figured under the name of *Buthotrephis gracilis* (greek word for living at the bottom of the seas) by Hall, in Palæontology of New York, Vol. II Pl. V f 1–3 represent the same species. For the largest of the plants has the main stem and branches 3.6 in. long, 0.16 in. to 0.2 in.

in diameter, while the smallest form is a plant about 0.8 in. long, in its whole, with threadlike stems and branches as thin as hairs, or like the divisions of some Confervæ.

The presence of the same species in different epochs of the Silurian, (the Trenton of the lower, the Clinton of the upper stage,) tends to prove the long persistence in life of some species or types of marine Algæ, a fact which has been remarked in other geological periods of the earth.

Only about 20 species of Algæ have been described from the American Silurian, some of them evidently mere varieties.

From the same formation of Europe, 5 species only are mentioned. Remarkably enough, all are of different types than those of America. The same can be said in regard to the isolation of the types of the fossil Algæ of Devonian age, of which we know about a dozen from each continent.

Especially remarkable for America are the species of *Spirophyton*, Hall, (spiral fucoid); membranous plants growing in a spiral or funnel shaped, transversely crossed with arched ribs or divisions, which, placed in rows upon another, look like the feather of a cock's tail; hence the general name of these plants, *Cauda galli*. They are extremely abundant in the rocks of Devonian age, and are found from the lowest to the highest strata, sometimes entirely covering rocks of great thickness. Passing upward into the Carboniferous, they are specifically modified like *Taonurus Colletti*, C. F. p. 7. Pl. A. f. 7.

Another remarkable kind of Algæ of Devonian age is *Dictyophytum*, (*dictyon* a fishnet,) whose flabellate or funnel-shaped fronds are vertically and transversely, black striated, forming in the interstices of the broad bands, square meshes like those of a fish-net. These plants, like those of the preceding genus have no known analogy to living Algæ, nor to any European fossil species. Still less is the splendid *Dendrophycus* (*dendron tree*, *phycos* seaweed) without relation to any other known plant, either fossil or living. A fragment of it is figured in C. F. Pl. LXXXVIII and described p. 699. The fronds of this beautiful plant observed in the red shale of the lower Carboniferous or Conglomerate measures of Pennsylvania and also in the Devonian of Iowa, were very large. One of them near Pottsville, which could not be detached from the rocks, measured nearly two meters (6½ feet) in length, and its ramifications on both sides, covered a surface of 2 ft. to 2⅓ ft. in width.

At the base and also in the upper strata of the Carboniferous measures of North America, some Algæ, of forms and characters still more peculiar than those of the Devonian, have been found, and described in C. F. Pl. A. & B. of the Atlas. Those referred to the genus *Conostychus* (*konos* skittle), Pl. B. figs. 1–4, resemble half round or conical cups, either solitary, narrowed to a short base, or superposed three or four upon another, in the shape of small round saucers, borne upon a cylindrical central axis, traversing through them all, from the lower to the upper. The species of *Asterophycus* (star-like plants,) are not less remarkable, the rays of these star-like Fucoids being either narrow, oblong, lanceolate, joined 6–8 by their base to a round central mamilla, C. F. B. f. 7, 8, or much larger, flat, straight, rounded at the apex, joined in the same number of rays to a large irregularly round stem, f 6.7.

Recent naturalists have thrown a doubt upon the real nature of some of the forms which phytopalæontologists have described as fucoidal remains, considering them either as impressions, or mouldings, produced at the bottom of the sea, or upon its sandy shores, by movements of the water, the footsteps of shells, or the boring of worms or insects. A Swedish naturalist, Prof. Nathorst of Stockholm, has even succeeded in artificially producing, by certain mechanical movements of water upon sand or mud, a series of figures similar to those considered by many authors as Fucoids. He has also reproduced the tracks of some animals, mollusks, fishes, worms, etc., made under his eyes by their movements upon soft matter, in figures which show a remarkable likeness to those published by palæontologists as supposed species of Fucoidal plants.

These critical observations, related to the determination of fossil organisms, do not in any way contradict the presence of remains of marine plants in the old palæozoic times. Though the number of species of Algoids described, especially from the old formations is limited, the luxurance of their vegetation in the ancient epochs is proved by the prodigious abundance of fucoidal remains in strata of both the Devonian and Silurian ages. Some rocks of these formations are not only covered, but really filled, for hundred of feet in thickness, with fossilized marine plants. Such are the beds of *Harlania* in the Juniata Valley. But if the plants of this species are quite distinct, (apparently of an original hard, horny texture) those of some other strata are, as remarked already, mixed together so closely, and in such profusion, that it is very difficult to recognize their real forms and their true characters. The ear-like and multiform Fucoids (*Fucoides auriformis* and *F. heterophyllus*,) of the Clinton group are of that kind. They may be counted by hundreds of specimens upon a surface of a few square c. m. One may really say, that the evidence of a primordial marine vegetation, in strata of the Devonian age especially, is as striking as that of a land vegetation in the Coal measure age, as evidenced by the remains of land plants upon the shale of the coal. I have remarked already in a memoir on *Fucoids in the coal measures*, that the superabundance of the vegetation testified by fossil remains in the Palæozoic ages, is in concordance with one of nature's most evident phenomena. The amount of carbonic acid gas is known to have been, in Palæozoic times, far greater, both in the atmosphere and in the water of the seas, than it is now. The prodigious luxuriance of the vegetation of the coal period is rightly ascribed to this fact. It can not be supposed that in the seas the vegetation, which there also is the intermediate agent between animal life and unorganized bodies gaseous or mineral, should have been in a diminutive state, when its action was most in demand for the purification of the water, and for the transformation of superfluous carbonic acid into organisms and oxygen ; and indeed for the harmonious progress of the whole.

As during Palæozoic times animal life was not in a degree of activity proportioned to that of the vegetation, we must of course inquire into the reasons of the exuberance of vegetable life, and also ask what has become of the surplus of the generated materials. For everybody knows now that, in the workings of nature's productiveness, nothing of the material used is ever lost. As the leaves impressed upon the shale or sandstone of the Carboniferous discover to us not only the characters of the plants of the coal, but the whole vegetation of the period, and its result in the formation of the combustible mineral, coal,—so also, the remains of plants so profusely left in the rocks of the Devonian age disclose the purpose of nature and the results of its work in the deposits of mineral oil in the strata of the same age.

This however being an hypothesis, it is not to be maintained without offering some facts for its support.

When marine plants are heaped in great masses on sandy shores, they are rapidly decomposed, passing into a black soft paste, then to a glutinous fluid of the same color, exhaling a strong offensive odor, which permeates the sand.

No analysis of that decomposed matter has been made; but by the analyses of petroleum chemistry demonstrates that mineral oil and coal are both composed of the same elements. And as this last matter is proved to be of vegetable origin the other must be necessarily referred to the same. Some substances, which were formerly procured from decomposed marine plants only, are now more abundantly obtained from petroleum.

The changes to which land plants are subjected, in the successive phases of their transformation into coal, can be more or less openly followed now, in studying, first, the surface vegetation of peat bogs and the gradual transformation of the vegetable matter downwards to the bottom of the beds, where the peat has become soft and black, and where the decomposition of the vegetable matter has progressed already so far that most of the original forms of the plants have become undiscernible. Then passing to older deposits of the same nature (the peat bogs of the quaternary, or the lignite beds of the tertiary) the woody matter, more compact, quite black, but still soft, has lost in its appearance every trace of vegetable origin: except, perhaps, in some trunks of trees, which have become as soft as the black paste wherein they are found embedded. That black matter, though half fluid, is still a kind of peat, which when dry, burns as freely as wood. Passing to still older formations of the same nature, those of the Tertiary, or of the Upper Cretaceous, the same kind of material now called *lignite* has, by longer continued decomposition become more compact, sometimes as hard as coal, presenting the same appearance of alternate, opaque and shining thin layers like that seen by vertically breaking a piece of coal.

But the matter is not yet true coal; it is still too soft, easily disintegrated, even spontaneously set on fire, when exposed to atmospheric influence. Its slow decomposition has to be continued for ages, until, still more hardened by gradual elimination of gaseous elements, it becomes, first as coal, then as anthracite, one of the most important agents of the civilization of the human race.

Gradual transformations of that kind, showing up the intermediate phases of alterations of the hydrophytes toward their ultimate conversion into mineral oil, have not been observed yet, as far as I know. Who can say what becomes of the fluid matter resulting from the first decomposition of dead Algæ; how it is gathered after effusion from the plants; and in what kind of reservoirs it has been preserved during geological times, and the changes through which the original elements have passed for their complete transformation into mineral oil or bitumen? In the Carboniferous formation are beds of Cannel coal so abundantly impregnated with bitumen that it blazes in burning like oil, and that even the bituminous matter, either partly remained fluid or set free by gradual decomposition, percolates through the underlaying shale and sandstone, and comes out at the surface of the springs, of the country around. It is the case with the Breckenridge coal of Kentucky. Though Cannel coal is considered as resulting from a more complete decomposition of fully immersed debris of aerial plants, it is possible, even probable, that in some localities the remains of marine Algæ have been casually thrown upon the surface of swamps inhabited by land or fresh water plants, and that then partly entering into the composition of the coal they have increased the proportion of free bituminous matter.

Near Green River station, in Wyoming, the strata (lowest Tertiary) along the river are built up, for 500 feet of exposed measures, of beds of shale, in thin laminated layers, mostly of argillaceons hardened clay or sand. These beds, or composite strata, sometimes of great thickness, alternate with deposits of black bituminous shaly materials 5 to 7 feet thick. The argillaceous sand or clay beds, which are by far the largest part of the series, hold sometimes in their composition a prodigious quantity of small fishes, flattened of course, and of which the bony skeletons only and the scales covering them are alone preserved. These deposits of fishes are in no way connected with or related to the black bituminous shale, being sometimes at a great vertical distance and having besides, with the skeletons of fishes, leaves or fragments of land plants: Poplar, Maple, Oak, etc.

In the black shale, no remains of organized bodies are recognizable, except a few scattered scales of fishes; and nevertheless they contain such a large proportion of bitumen that, looking like beds of coal, they have been often quarried and used as combustible material, though they are not coal. They burn easily, but do not consume. This bitumen can not be derived from fishes, since all the layers where fishes are found are free of any trace of that matter; it is evidently derived from vegetation, but not from marine Algæ, as the whole formation is of fresh water origin. The decomposition of the materials has gone on evidently in shallow lakes, filled by an active vegetation of fresh water hydrophytes, like Confervæ; and the bitumen resulting from their decomposition has been infused into the muddy matter deposited at the same time. In the same way, a more luxuriant vegetation of Algæ in marine formations may accumulate a mass of its remains in some localities. The matter being gradually decomposed and partly transformed into a bituminous fluid, has been distributed either into clay beds by diffusion, or preserved in reservoirs formed by the space occupied originally by the vegetable deposits. Still the process of decomposition remains unknown.*

These cursory notes on the Hydrophytes may serve as an introduction to more detailed remarks on the land vegetation of palæozoic times.

Progress of Palæozoic land vegetation.

The plants of the palæozoic times are mostly referable to four divisions or orders of the vegetable kingdom; the *Ferns*, (*Filices*,) the *Calamarieæ*, the *Lycopodiaceæ*, and the *Cordaiteæ*. The first three orders belong to the class of cryptogamous acrogens plants; the third, not represented in the Flora of the present epoch, is of a higher degree of organization and takes its place between the *Cycadeæ* and the *Conifers*, being related by some characters to both of these orders of plants.

As far as it is known, until now, the first traces of land-plants appear in the lower Silurian, the Trenton group. There have been found in strata of that formation (the Cincinnati limestone and described from them, a *Psylophitum*) (*Psulon* floating plant), a genus of the Lycopodiaceæ, a *Sphenophyllum* of the Calamarieæ, and a *Protostigma* (*protos*, the first, most ancient), part of a stem marked with rhomboidal, square, areoles like those of some *Sigillaria*. I have recently received from Mr. Ulrich, of Newport, Ky. a geologist well acquainted with the fossil organisms of the Cincinnati group, specimens of limestone from the base of the Trenton shale, near Minneapolis, Minn. bearing branches of a fine, extremely delicate species of *Asterophyllites*. From the Upper Silurian (the Clinton epoch) two species of *Lepidodendron* have been discovered; one, described under the name of *Glyptodendron* by Prof. Claypole, has bolsters, rounded at the apex; the other, found quite recently by Prof. Orton, has its bolster pointed; the two species therefore representing two different types. At a higher stage Upper (Helderberg) specimens of an *Annularia* and of a *Psylophiton* have been obtained in Michigan (*).

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* Years ago when I was occupied in researches upon the relation of the oil deposits to the decomposition of marine Algæ, the celebrated Chemist, Prof. Liebig, to whom I exposed my views, asking at the same time if they could be supported by the evidence of chemical analysis, kindly answered me: "That there were then unhappily no analyses of species of Fucus or of other Hydrophytes which could be used as affording support to my views. But that my arguments, based on exact researches, were so conclusive, that, for himself at least, they had removed any doubt of the truth of the theory."

At about the same time when these plants were discovered, a fine species of fern, *Eopteris*, was described and figured by Saporta, from the schists of Angers, France, a formation referred to the same age as the Cincinnati limestone.

Some doubts have been expressed about the reality of the reference of these organisms to land plants, on account of the insufficiently defined forms of the specimens, and also from the generally received opinion that land plants could not have appeared so early upon the surface of the earth, the great abundance of remains of marine animals in the strata of the middle Silurian, tending to prove a general submersion of the earth at that epoch.

But, first, we can not admit, or rather conceive, a general and total submersion of our planet. Even during the progress of the deposition of the Archean rocks there has been, of course, local differences in the levels of the surface; and though the whole planet was enveloped in a dark veil of heated vapors, land was exposed at divers localities; the only obstacle to the apparition of land vegetation being the high degree of temperature of the atmosphere and of the surface of the land. At the end of the deposition of this great general formation, which covered the whole globe with a thick crust of stratified materials, the temperature had already been lowered, and as Prof. Dana says, in his Manual of Geology, it could not be over 38° C. or 68° F. The mean temperature of the equator, is, according to Humboldt, 27° C. or 50° F. But, over the Archean rocks, and up to the middle Silurian age, 2000 feet of measures have been built up in the Primordial era, 10,000 in the Canadian and 6-700 feet in the Quebec and Chazy limestone above: So

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(*) These plants except the Lepidodendron species are described and figured in Proc. Am. Phil. Soc. Vol. XVII, N. 100, p. 163, Pl. IV f. 1-8.

that 12,000 feet of measures or more, intervening between the Archean and the Trenton group, indicate an immense length of time, many millions of years, during which of course the crust of the earth had been cooling, and the atmospheric circumstances greatly modified, becoming gradually less charged with vapors. Nevertheless, the atmosphere was still warm and humid, and favorable to a vegetation like that of the plants which have been described as the first land plants. (*)

Plants with well defined characters, and a strong organization, could not therefore be considered as representatives of the first land vegetation of the earth. While those cylindrical small stems, still without leaves (like the numerous fragments of *Psylophitum*, found by Prof. Dawson at the base of the Devonian, and which he considered as having been floated there from Silurian rocks, or the little fragile *Annularia*, *Sphenophyllum* and *Asterophyllites* of the Trenton epoch, which were apparently soft and growing in small shallow basins, of tepid water, or upon wet rocks) have just the appearance of plants newly born, derived perhaps from some peculiar kind of sea weeds, by a modification of their inflorescence. These first representatives of a new series of vegetables were rudiments easily moulded for the march of their future evolution.

The Ferns. (*Pteris.*)

In the Flora of the Palæozoic, the Ferns take first rank, by their preponderance, especially in the Carboniferous formations; by their presence in all the strata and nearly at all the localities where fossil remains of vegetables have been found; and also because they are the best known plants of the present epoch. Everybody knows the ferns and likes them. They do not bear brilliant flowers; but the pleasant green color of the plants, the elegance of their drooping fronds, the delicateness of the forms of their

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(*) DeCandolle in his Geographie Botanique remarks that great heat and much humidity produce, as we see in the plants of the greenhouse, weakness of tissue and a semi-chlorosis, which does not allow the plants to follow satisfactorily the divers phases of their development.

leaves, admirably cut in elegant fringes of the most diversified patterns, everything about these fragile inhabitants of our woods renders them if not dazzling to the eyes, at least always lovely and attractive-like old friends.

Ferns are perennial, herbaceous or arborescent plants. As herbaceous, they do not grow very high, but sometimes cover with their sole vegetation large areas of wet or shady grounds. Not that they always need shade for favoring their growth, which essentially depends on atmospheric humidity; for near the borders of the sea or of swamps, or upon mountains, where the atmosphere is generally charged with vapors, they thrive to a high degree of luxuriance, even under the constant light of an ardent sun.

As trees, their trunks, 3 to 50 feet high, are clyindrical, straight, without branches, like vertical columns crowned by a profusion of long lanceolate fronds, gracefully curving back like the leaves of Palm trees, which they somewhat resemble. The trunks bear deep scars upon their bark, impressions of the points of attachment of the base of the petioles of the fronds. These scars being of different size and conformation, and also placed in various relative position, serve to characterize and determine the plants.

In the Palæozoic formations, especially in the Carboniferous, trunks of fern-trees are not very rare, and are often found silicified in beds of sandstone. They are then, mostly, horizontally broken into fragments of various thickness. Shade river in Ohio is a locality well known for the abundance of fossil remains of this kind, found in the bottom of the creek and in the country around. In former years, I have seen parts of trunks from 4″ to 2 feet in diameter, some of them as long as thick, showing, distinctly marked upon the transverse sections the texture and therefore the real characters of the plants. When polished, the horizontal sections represent the details of structure like beautiful drawings, or modifications of forms and color resembling those of the finest kinds of marble.

The leaves of ferns and their branches are, before their evolution, rolled up in spiral, like watch springs in their barrels. Impressions of these unfolding, still undeveloped parts are sometimes found upon the shales of the coal measures and described under the name of *Spiropteris*. (1).

The ferns have no flowers. Their organs of reproduction are generated upon a green prothallium (primitive blade or organism) produced from the germination of the seeds, and upon which the organs of generation (antherids and archegones,) are separately born. This primitive tissue soon disappears after the young plant has taken life. The prothallium is designed to be the first food of cryptogamous plants, like the cotyledons of dicotyledonous plants. But the fructifications of ferns have no likeness to those of other kinds of vegetables. They are mere small capsules (sporanges) formed of the parenchyma of the leaves, and generally attached to the lower surface, or under the recurved borders of the leaves, joined together in glomercules of various forms, round, semi-lunar, oblong, linear, etc. The sporanges are ordinarily covered by a thin membranous envelope (indusium) very rarely observable in the fossil state. Sometimes they are composed of the whole tissue of the leaves; and then the fructified part is modified and takes a far different aspect from that of the sterile fronds. C. F. Pl. XLVIII f. 8–10, Pl. C., f. 4, 5.

The ferns of Palæozoic times, especially those of the Carboniferous, have been generally of the same types over the whole land surface of the earth. This fact is easily accounted for by the general sameness of the atmospheric circumstances, especially by the great amount of humidity with which the atmosphere was then charged. There are however marked differences indicated by the characters of the species. We see, for example, that although 330 species of Ferns have been described from the Palæozoic measures of the United States, only 109 of these are as yet identified with those described by European authors. This difference is evidently too great, and due to uncertainties of determination, will probably be reduced when Palæontologists have an opportunity of comparing specimens

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(1.) The termination *pteris* is often added to the names of genera of ferns, the roots of the names being generally derived from the Greek.

from both continents. We have nevertheless, in North America, distinctly characterized genera, like *Megalopteris*, represented by a number of species which as yet have not been observed in Europe. The same may be said of a number of European genera, of which no representatives have been as yet seen here. This is not surprising, for the geographical distribution of the ferns has always been subject to some unexplainable peculiarities. At the present epoch, for example, of the 60 species now living on the Eastern slope of the United States, only 15 are found in England. Of the 43 species on the Western slope, only 8 are found on the Eastern, and 10 in Europe. Half of the species of Europe are found also in the Himalaya mountains; and so on.

Excepting trunks, rhizomas, petioles, and other fragments of organs of which the determination is not possible, the number of species of fossil ferns known from all the geological formations amount to about 700; while more than 3000 species of living ferns are known.

Specimens of fossil ferns bearing fructifications are comparatively rare. More, however, have been found in America than in Europe. As at the present epoch the tree-ferns more rarely bear fruits than the herbaceous species, it has been supposed that most of the Ferns of the Palæozoic were trees; and this conclusion might be accepted for a peculiar tribe, the *Pecopterids*, whose fronds are pinnately divided. But most of the species of the Carboniferous, and some of the largest in size, like the *Neuropterids*, of which the fructifications are still uncertainly known, have a dichotomous ramification, and appear therefore to have been bushy ferns.

Distributions of the Ferns; characters and affinites of the groups.

In the American palæozoic measures, no remains of Ferns have as yet been found lower than the middle of the Devonian age. In a paper on the Devonian plants of Eastern America, Prof. J. W. Dawson (*) has given a comparative

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(*) On the Flora of the Devonian Period, Quat. Journ. Geol. Soc. 1862.

list of species represented in the Upper Silurian, the lower, middle and upper Devonian of Canada and the United States; and in that list he mentions *Cyclopteris incerta* from the middle Devonian of New York; and from the upper Devonian of Maine *C. Halliana*, and *C. Jacksoni*. The first of these species is represented as small branches, bearing slender curved ramules, to which are attached groups of indistinct glomerules, which may be flowers, but which, taken altogether, are too uncertainly defined (as the specific name indicates it) to permit consideration. The two others, however, are of a peculiar distinctly characterized type of ferns with which this examination will begin.

Archæopteris.

Archæopteris, (*archaios* ancient.) C. Fl. Pl. XLIX. These peculiar ferns, first named *Cyclopteris* (*cyclos* circle) compose now, with a number of other species, the genus *Archæopteris*, whose plants are generally of large size, with long, erect, opposite, lateral branches; the leaves sessile upon the branches, or even upon the stems, alternating, wedgeform, narrowed to the point of attachment, more or less enlarged at the apex and are there entire; crenulate, dentate or even laciniate; the nerves, all of the same thickness, are thin, straight, emerging from the base and dichotomous in ascending.

From the Devonian upward, six species of *Archæopteris*, including the two formerly mentioned, have been found in the Catskill group of Pennsylvania, especially at Meshoppen and Coxton narrows. Then, higher up in the measures, Prof. B. F. Meek discovered three species at the point of union of the Catskill Red Sandstone with the Sub-carboniferous measures, near Lewis Tunnel, Virginia. One species also was obtained by Prof. Fontaine, from the New River coal measures; and later still, Prof. E. B. Andrews found, near Rushville, Ohio, three species of *Archæopteris* in a thin bed of bituminous shale barren of coal, apparently formed of the deposit of marshy plants upon a swamp of very little extent. According to the report of Prof. Andrews the geological horizon of the shale is in the Waverly sandstone, near the Chester limestone, a little above or below it. The Chester group in Illinois and Indiana apparently takes the place of the Pocono sandstone of Pennsylvania.

Relying on the indication given by the plants, the Rushville bed should be the equivalent of the Lewis Tunnel bed and of the New River coal measures, and thus indicates the place of the Chester group at the very base of the Sub-carboniferous measures, like that of the other localities where species of *Archæopteris* have been found.

There is, however, a great difference in the distribution and composition of the measures at the localities named above. Difference is especially seen in the nature of the materials which have entered into the formation of the deposits.

In Illinois and Indiana the Chester group is a series of alternating beds of limestone, sandstone and shale. No coal has been found there, except one or two very thin beds, seen in the upper part of the group.

In Northern Ohio and Pennsylvania, the Berea grit and other strata, are overlaid by Sub-carboniferous measures of little vertical thickness, with two or three beds of coal, worked at Cuyahoga Falls, Youngstown, Sharon, etc. This is the case also in Arkansas.

In Virginia, Alabama, Georgia, etc., the productive Sub-carboniferous measures, begin at the very top of the Catskill group, and have a thickness of more than 2000 feet, comprising numerous beds of coal, from 4 to 12 feet thick, interposed between strata of limestone, sandstone, iron, etc.

This short explanation, will help to better understand the distribution of the plants, and their relation—to the Sub-carboniferous measures.

On the genus *Archæopteris* I remark further, that its largest form of plants, with great branches and leaves 2½″ long 2″ broad, near the apex, or larger still than the branch of *A. obtusa* in C. F. Pl. XLIX f. 7, was found at Montrose in the Catskill group.

Later in the formations, especially at Lewis Tunnel and Rushville O., plants of the same genus, are seen to have become much reduced in size, bearing, small very delicate leaves; and the genus then apparently became extinct.

Megalopteris.

The case is the same with the following still more remarkable genus, *Megalopteris* (*megas* great). C. Fl. Pl. XXIV, fs. 1–3. The plants of this genus, known only by fragments of stems, have oblong-lanceolate leaves, alternately placed upon a thick rachis and long broadly decurring on it; they have a thick mid-rib, curving backwards in passing towards the borders, and dichotomous or forking. Figure 1 of Pl. XXIV, loc. cit. of a species of this genus, scarcely gives an idea of the size and beauty of the fronds, which, on account of their size, can be obtained only in fragments. Part of a leaf found near Port Byron, Ill., of which a fragment was 4½ inch. in diameter, was at least 28 inch. long, the leaves being generally 6 times as long as broad.

This species appears first in the sub-conglomerate series of New River. It is also found, with species of the preceeding genus, in West Virginia; then at Rushville; and last of all at Rock Island, Ill. in the lowest carboniferous strata of the locality which appear to correspond with the Chester group. It therefore follows the same distribution as *Archæopteris*, appearing a little later, but remaining also a little longer in the flora. It seems however to become extinct, like *Archæopteris*, at the base of the Subcarboniferous; but imparts some of its most important characters to the genus *Neuropteris* (*neuros*, nerve) which, then makes its appearance and gradually contributes in large proportion to the richness of the Coal Flora.

NEUROPTERIDS.

The *Neuropterids* form a peculiar group, which, from analogous characters of nervation, include the genera *Neuropteris*, *Odontopteris* (*odous* a tooth,) *Lesleya* (a personal name,) *Dictyopteris* (*dictuos* a fishnet,) *Neriopteris* (*nerion* oleander,) *Megalopteris* (*megas* great,) *Tæniopteris* (*tainia* ribbon).

Neuropteris. C. Fl. Pl. V–XVIII. The characters of those beautiful ferns, are partly indicated by the name. Plants generally large, bushy, dichotomous in the lower divisions, pinnate in the upper, pinnæ large, lanceolate or narrow, linear-lanceolate, pinnules round or cordiform, lanceolate, oblong, obtuse, rounded at base, mostly entire, all attached by the base of the medial nerve sometimes prolonged into a short pedicel, or by the middle of the rounded or cordate base of the leaves, lateral nerves very close, thin, arched in passing toward the borders from the medial nerve, or fan like from the very base. The genus shows divers forms of leaves and also divers modifications of the nervation, according to the presence and absence of a midrib.

Odontopteris, C. F. Pl. XX–XXII, merely differs from *Neuropteris* by the lateral nerves emerging straight and parallel at base, from the rachis or from the medial nerve.

Lesleya, C. F. Pl. XXV, f. 1., resembles *Neuropteris* and especially *Megalopteris*, by the size of the leaves and the nervation, but differs by its narrowed base.

Dictyopteris, C. F. Pl. XXIII, f. 4–10, has the leaves of the same form as those of *Neuropteris*, differing by the nervation, the lateral nerves traversing the lamina in undulations, anastomosing at their points of contract, forming ovate or polygonal meshes like those of a fish-net.

Tæniopteris, C. F. Pl. XXV, f. 7, has long, linear ribbon like leaves, with a broad medial nerve from which the lateral ones, which are very close, emerge and pass at right angles to the borders.

Neriopteris, C. F. Pl. XXIV, f. 4., has leaves like those of *Neuropteris*, but comparatively narrower and with borders reflexed.

In comparing the leaves of *Neuropteris* and *Megalopteris* C. F. Pl. XXIV it will be easy to perceive the great analogy of the characters, of the leaves of the two genera, and admitting derivation, to follow the evolution of the others from the original type. The evolution is to be more likely admitted, from the fact that the original habitat corresponds with the affinity of the characters. All the genera appear in the Sub-carboniferous, where *Neuropteris* has already 14 species ; *Odontopteris* 7, *Lesleya* 2, *Megalopteris* 13, *Tæniopteris* 2, and *Neriopteris* 1. Of these, *Megalopteris*, *Tæniopteris*, and *Neriopteris* do not pass above the Millstone grit (or Pottsville conglomerate) into the Middle coal measures. But *Neuropteris* is very persistent and becomes more widely distributed in the Middle coal, where it is represented by 40 species, 4 species only of those of the Sub-carboniferous having passed above it. In the Permo-carboniferous the genus has still 7 species, 3 of which exclusively pertain to this stage.

Of the species of *Odontopteris*, 3 are lost in the Sub-carboniferous ; but still it has 22 in the Middle coal measures and 4 in the Permo-carboniferous ; three of these are new species and one, an European form, not recognized in the lower measures.

Of *Dictyopteris*, a single species, *D. obliqua*, appears in the coal shale of Arkansas, where some separate leaflets of the genus have been found. The genus has 5 species in the Middle carboniferous. They are scantly represented, and do not appear in the higher divisions.

In order to see that the species attributed to the Sub-carboniferous are not casual, or mere local species, it is well to remark that those which do not pass above the Millstone grit have been found at three or four far distant localities. For example, *Neuropteris Smithii*, *N. Elrodi*, *N. biformis*, have been found in the coal measures of W. Virginia, Georgia, Tennessee, Alabama, Arkansas and the Whetstone beds of the Chester group in Indiana. Of the species passing above, *Neuropteris tenuifolia* is present at 4 localities. It is the same with most of the others ; they have been observed, in at least 2 or 3 localities. In a single tribe of ferns we have, therefore, sufficient data for the identification of the different stages of the coal measures. The discovery of *Neuropteris Smithii*, for example, which was repeatedly sent to me from Alabama and Virginia, was sufficient authority for the reference of the Alabama coal fields to the Sub-carboniferous measures, a reference generally and persistently doubted at the beginning of the working out of the remarkable coal fields of that State.

ALETHOPTERIDS.

The two essential genera pertaining to this tribe are *Callipteridium* and *Alethopteris.*—*Callipteridium* (*Kalos* beautiful) Pl. XXVII, is like a transitional link, between the Neuropterids and the Pseudo-Pecopterdis which follow.

The plants are pinnately divided, the leaflets are attached by the whole decurring base; the medial nerve is thick, the lateral fine, numerous, curved back in passing toward the borders, forking once or twice. The nervation is analagous to that of *Neuropteris;* while the division of the pinnæ is like that of *Alethopteris.* Twenty species of this genus are described from the American Coal measures; 5 in the Sub-carboniferous, 2 of which pertain only to that stage; 18 belong to the Middle coal; and 5 new species have been described from the Permo-carboniferous. To this may be added *Callipteris conferta*, a plant very abundantly observed in the Upper coal measures of Europe and in the Permo-carboniferous of America, but not seen as yet in the lower stages.

Alethopteris (*alethos*, true,) C. F. Pl. XXIX, especially differs from the preceding by the lateral nerves at right angles to the midrib and straight in passing to the borders.

Of the 17 species of this genus, 6 belong exclusively to the Sub-carboniferous; 2 pass above to the lowest coal strata of the Middle carboniferous, where 7 more species are present; and 2 belong exclusively to the Permo-carboniferous. The genus is essentially characteristic of the low coal.

PSEUDOPECOPTERIDS.

This tribe is intermediate between the preceding and the following. It differs from both, by the dichotomous divisions of the rachis. It has one genus only.

Pseudopecopteris (*Pseudos* false) C. F. Pl. XXXII, XXXIV, XXXV. Plants large, with dichotomous branches, pinnules joined or separated at base, variable in form and size, oblong, obtuse, or ovate-lanceolate, at right angles, or oblique to the rachis, sometimes decurring to it and bordering it by a narrow wing; lateral nerves oblique and curved, generally forking once, the lower pair twice.

Thirty-five species are described in this genus; of which 18 are present in the Subcarboniferous; 6 pertaining exclusively to it, passing above the Millstone grit, are mostly found in connection with the lowest strata of coal A & B, few passing above coal C. None have been observed in the Permo-carboniferous.

By some of the characters, the plants of this tribe, are related to the *Neuropterids*, their nervation being like a combination of that of *Odontopteris* and *Callipteridium*. They are allied to the *Pecopterids*, but all the species have a marked degree of affinity among themselves; and taken all together, they form a distinct and natural group, which had to be separated under a proper name. From the multiple relations of the characters, the species have been referred by authors to *Pecopteris*, *Alethopteris*, and a few to *Sphenopteris*.

PECOPTERIDS.

Two genera: *Pecopteris* and *Oligocarpia* compose this tribe.

Pecopteris (*peko* to comb) C. F. Pl. XXXIX, XLVI. Mostly tree ferns. Fronds pinnately divided from the base; pinnæ linear-lanceolate, acute, sometimes very long and narrow; pinnules attached to the rachis by their whole base, free or connate at base, small, oblong, obtuse, entire or denticulate; medial nerve strong, pinnately divided into simple or forking veinlets. In this genus and the following, the basilar nerves do not come out of the rachis as in *Alethopteris*, but all are derived from the midrib.

The plants of this genus appear later and are mostly distributed in the Upper coal measures. Of 93 species described from the American coal fields, 7 only are present in the Sub-carboniferous, 3 of them not seen above and 4 in the inter-conglomerate. All the others are distributed in the Middle coal measures and in the Permo-carboniferous which has comparatively the greater number, 40 species, of which 15 only have been preserved in the Middle coal measures. No less than 25 new species have been described by Messrs. Fontaine and White, in Report PP, from the Upper carboniferous of West Virginia.

Oligocarpia, (*oligos* few, *karpos* fruit) C. F. Pl. XLVIII, f. 1–3, a genus of three species only, differs from *Pecopteris* merely by the characters of its fructifications. The species are rare and of no importance in geographical distribution.

SPHENOPTERIDS.

This group, composed of a single essential genus, has been diversely subdivided by authors.

Sphenopteris (*sphen* wedge, from the basilar form of the leaves) is, by the number of its species, the most important genus of the Palæozoic ferns. It must be remarked, however, that on account of the minuteness of the plants of some species, the great variety in the subdivisions of the fronds, and the diversity of forms of the pinnules, the determination of fragments has certainly unduly increased the number of species, by wrongly considering as different, branches pertaining to the same plants.

These plants are repeatedly dichotomous, or polypinnate, with divisions often at right angles; pinnæ lanceolate; pinnules narrowed at base, wedge form, often decurring and bordering the rachis by their prolonged base; pinnately or more or less irregularly lobed; lobes rarely entire, crenulate, dentate or laciniate; primary nerve (medial nerve of the pinnules) slender, alternately dichotomous, the branches entering the base of each lobe, to pass by branchlets into the subdivisions of the pinnules.

According to peculiar characters the genus *Sphenopteris* is divided into 4 sections, which are in concordance with the geographical distribution of the plants.

Sphenopteris (*Pecopterid*,) Fronds with ultimate pinnæ, deeply lobed; lobes united to the middle or higher; veins pinnately divided as in *Pecopteris*. C. Fl. Pl. LV, f. 3, 4.

Eight species belong to this group, 3 of which, pertain exclusively to the Sub-carboniferous the others also in the Sub-carboniferous pass to the lowest strata of the Middle coal.

Sphenopteris (*proper*.) Pinnæ more deeply divided in lobes or pinnules narrowed and decurring at base, generally dentate or crenate at apex. C. Fl. Pl. LV, f. 1–3a.

Of twelve species referred to this division, 3 are Sub-conglomerate, the others are generally distributed in the measures and ascend to the Upper coal strata.

Sphenopteris (*hymenophyllites*). Fronds polypinnate; axis of the ultimate and penultimate divisions composed of narrow linear fascicles of nervilles,. mostly united into a simple, rarely double nerve, bordered by a linear narrow blade repeatedly dichotomous, lobes entire, linear, obtuse or narrowly lanceolate, acuminate, rarely uniform. C. Fl. Pl. LV, f. 5–9.

In this subdivision, which I have considered as a genus, 25 species are described, of which 12 are found in the Sub-conglomerate measures only; 5 others pass above to the lowest beds of the Middle coal measures, only three going up to coal B.

Eremopteris (*eremos* solitary) C. Fl. Pl. LIII. The lateral nerves enter the lobes in an acute angle of divergence, from the midrib, passing up to the borders and dichotomous; they are flabellate and curved back, sometimes close as in *Neuropteris*.

Of the 8 species, 5 of this division are limited to the Sub-carboniferous, 3 only passing above to coal A.

In the Permo-carboniferous measures, 9 species of *Sphenopteris* of a peculiar character and without relation to those of the lower coal have been described in Report PP.

From this it is seen that a remarkable number of species of *Sphenopteris* enter into the flora of the Sub-carboniferous measures, which in Europe are considered as a separate member of the Carboniferous and named the Culm.

We have yet to mention, in the Ferns, the genus *Rhacophyllum*, which, as its name indicates, describes remains of ferns considered parasitic, i. e., growing upon the rachis of other ferns or at their base. These plants are extremely variable in their characters, and do not indicate, by their habitat, any relation to a peculiar geographical distribution. They have been rarely found below the Conglomerate (Millstone grit).

It is necessary to mention also the trunks, which, as it has been remarked above, are determined by the scars left at the base of the petioles of the fronds attached to them. They are described in the three following genera.

Stemmatopteris (*stemma* crown) C. Fl. Pl. LIX. Trunks with large disciform, oval or round scars, not contiguous, disposed in quincuncial or spiral order, surrounded by a flat ring; internal disk formed by impressions of fascicles of vascular tissues, horse shoe shaped, the horns curving inward in the upper part of the scars, either short and hooked or descending below the middle of the scars and then united.

Fifteen species are described in this genus, one Sub-carboniferous, the others ascending higher, most of them as high as coal C.

Caulopteris (*kaulos* stem) C. Fl. Pl. LX. Scars with the inside disk marked by linear bands, remains of vessels passing from the wood to the base of the rachis, or covered by impressions of rootlets, obliterating their shape, ovate or elliptical, without traces of the horse-shoe-shaped vascular lines.

Of 8 species known of this genus, 3 have been found in the Catskill group; 4 in coals A to C of the Middle coal measures; one in coal F.

Megaphytum (*megas* great) C. Fl. Pl. LXI f. 4. Scars large, round, quadrate in outline, generally contiguous, the lower, somewhat distant, placed in opposite biserial rows, internal disk convex, with central or vascular horse-shoe shaped impressions, or a medial band dividing the disks into two lobes joined in the middle.

The disposition of the leaves in two opposite rows and close to each other is very peculiar, not seen in any fern-tree of the present time.

Four species are described from the American coal measures, distributed from coals A to M.

A few fragments of rachis of ferns have been described as *Rachiopteris* Pl. LXXV, f. 7; and inflated bases of stems of rhizomas, as *Stigmarioides*, Pl. LXXV, f. 1–5.

CALAMARIEÆ (*Calamos* reed.)

The *Calamariæ* are considered as a tribe, or a correlative order of the *Calamarieæ* or *Equisitaceæ* (Horsetail family.) This last, at the present epoch, is represented by a few species of herbaceous plants of small size; and in the coal measures of America the remains referred to this tribe are as yet very rare, merely a few sheaths, of which the characters are still indefinite.

We have therefore to consider only the *Calamariæ* whose vegetation has had in Carboniferous times an importance, of which it is scarcely possible to have an idea now.

The stems of the *Calamariæ* are hollow, articulate, traversed at the articulations by a strong membrane, (the diaphragm) striate or costate lengthwise; the leaves, placed in verticiles at the articulations are narrow, linear-lanceolate, wedge-form, uni-or plurinerved, free to the base, or merely united at the very base; the branches are produced upon the articulations in the axils of the leaves.

The essential difference between the fossil *Equisitaceæ*, and the *Calamariæ* is in the leaves; which, in the first tribe, are united and connate to above the middle in the form of sheaths; while, as said above, they are free to the base in the *Calamariæ*. European authors, have described these sheaths under the name of *Equisitites;* but Schimper remarks that, the organs of fructification of these plants being unknown, it is not possible to say if by a kind of deformation they belong to the *Calamariæ* or are representatives of the *Equisitaceæ*. The distinction seems however forced upon us by the geographical distribution of the plants, the *Calamariæ*, being all in the Carboniferous and not passing above, while the *Equisitaceæ* appear and progress especially in the Mezozoic times.

The plants of the *Calamariæ* are distributed into the genera *Calamites*, *Bornia*, *Calamodendron*, *Asterophyllites*, *Annularia Sphenophyllum*, and their fructifications, *Calamostachys*, *Volkmannia*, and *Macrostachya*.

Calamites. C. F. Pl. I. Plants arborescent, derived from a subterranean zhizoma; stems, as described for the *Cala-*

mariæ, attenuated to the base; stem leaves fugacious, very rarely seen attached to the trunks, leaving, as marks of their points of attachment, small half round tubercles. often absent; branch-leaves longer than those of the stems, linear, acuminate, free to the base, very entire, simply nerved, in open or erect verticils around the articulations; fructifications in spikes or catkins, at the end of branchlets, bearing in verticils, small globose sporanges in the axils of the leaves. Fructifications of this kind have not been found in connection with any stems of *Calamites;* they are however, seen with those of *Asterophyllites*, which are considered by some authors as their branches.

The *Calamites* were plants of rapid growth, living upon soft muddy ground, where their cylindrical articulate rhizoma, creeping near the surface, and forming in their growth a matting of more or less compact matter, emitted from their articulations, stems narrowed to their point of attachment, either curving upward and ascending treelike, or remaining prostrate upon the matting. They grew therefore close together, associated in groups, their stems varying from one to 10 inches or more, reaching an altitude of 15 to 30 feet.

A standing forest of *Calamites*, embedded in sandstone, has been traversed near Carbondale, Pennsylvania, in tunnelling for a sloping gangway to a bed of coal under the sandstone. From the materials taken out of the tunnel a long tramway at least 3 feet high, has been constructed, mostly made of fragments of trunks of *Calamites*. Their thickness varies from 3½ to 6 inches in diameter; and the distance between the trees, as far as it could be measured upon the walls of the tunnel, is only 8 to 12 inches. The trees were therefore, growing very close together, forming dense thickets.

It is certainly not possible to say whether the *Calamites*, or any other plants of the coal, were annual plants, that is, we cannot measure their growth by limited periods of time, like those which now mark the seasons. But evidently their growth was rapid and uninterrupted; and probably their debris were not gradually or successively deposited in fragments; but prostrated in masses upon the surface; just as it now happens with some of the plants which enter into the composition of peat; the Birch, for example, in Denmark; the Tamarak, in the peat bogs of Minnesota; the Canes, in the Dismal Swamp of the South. These vegetable forms, either trees or herbaceous plants, often grow there so compactly, their stems so close together, that none of them fall separately. When their term of life is reached the whole mass leans over gradually and by and by, under the influence of some atmospheric casualties, snow or wind, or loosened by basal rustiness, it is prostrated altogether, covering the surface of the ground with a thick coating of stems and debris. Through this mass, and after a short time of decay, a new outsprouting of the same kind of plants makes its appearance, and the phenomenon is repeated again and again. It is in this way that we may account for the composition of some beds of coal entirely made of remains of *Calamites*, or of other peculiar plants of the Coal period.

The characters for the descriptions of species of *Calamites* are taken from the length of the internodes (the space between the articulations); from the shape and position of the tubercles or leaf-scars above or below the line of the articulations; from the depth and width of the striæ, and their contiguous or alternate position where they come together. It has been found however, that all these characters are subject to more or less variation, and are therefore unreliable, and thus the number of species remains undefined.

Schimper, in his great work on vegetable palæontology, describes 7 species of *Calamites*. Of one species of the Permian, Schlotheim makes five. Other authors have a much larger number; while Ettinghausen, a justly celebrated German Palæontologist, finding the characters of *Calamites* too inconstant for precise determination, reduces all the species to one, *C. variabilis*, considering all the different forms as mere varieties.

From recent discoveries published by European authors, and from what has been observed of these plants in the

North American coal measures, I have admitted 12 species. Of these, 7 are found in the Sub-carboniferous measures, all except two, passing above and generally distributed, but gradually becoming less predominant in ascending the measures. A few remains of a single species of *Calamites* have been found in the Permo-carboniferous of America; and 5 species are described from the Permian of Europe, all rare, three of them being new species from Russia.

Bornia.—This genus has one species only, made by uniting *Calamites radiatus*, with four other so called species; among them *C. inornatus* and *C. transitionis.*

The genus merely differs from *Calamites* by the articulations not being contracted, marked only by a transversal line squarely cutting the striæ, which thus appear continuous or scarcely interrupted. Leaves, linear or lanceolate. A specimen of *Calamites radiatus*, figured by Brongniart, has the articulations bordered by verticils of large lanceolate leaves; others, figured by different authors, have narrow thread-like leaves, fasciculate and split or bifid. Of the numerous specimens which I have examined of this species I have seen none but that figured C. F. Pl. XCIII, f. 2, with the verticillar appendages. As the figured fragment (a mere branch) is obscured by a thin leaf which covers it, and through which the more prominent features only are marked, the real form of the leaves cannot be distinctly observed.

Bornia radiata, the only species known, is distributed merely in the Sub-carboniferous measures, from its lowest strata upward. The specimen described as *Calamites inornatus* is from the Genesee epoch; that of *C. transitionis* is from the Hamilton group (middle Devonian).

Calamodendron. Considering the American specimens which I refer to this genus, they differ from *Calamites* by their thick woody bark. C. F. Pl. LXXV. f. 16., XCII, f. 5. Except this, it is scarcely possible to point out a difference between these specimens and a number of those referred to *Calamites approximatus*, one of the most common species of the Carboniferous. The French authors Grand 'Eury & Renault, especially ascribe the genus *Calamoden-*

dron to the Phanogamous (Dicotyledonous-gymnosperms) while Schimper & Cotta for the Germans, Binney and Williamson for the English, persist in considering it as referable to the *Calamariæ.* American specimens cannot (as yet) afford any light on the subject, as we have so far none silicified and preserved with the texture of the stems. I have however seen, from the Permian of the Rocky Mountains, large fragments of cylindrical stems, marked on the outer surface with close articulations and striæ, like those of *Calamites.* But on breaking them they show, from the outside to the center, a succession of layers, all marked by the same characters, close articulations and striate internodes. The fragments are apparently of the same kind as the trunks with successive concentrical layers which Grand 'Eury has described under the name of *Arthropitus*, and which, indeed, do not seem to have any relation to the *Calamariæ.*

Asterophyllites (*aster* star, *phyllon* leaf) Pl. II f. 3. Considered as leaves of *Calamites*, those plants do not require any other definition but that given above of the genus.

These branches are often found in profusion at localities where no fragments of the trunks of *Calamites* are to be found. But this does not contradict their reference to the *Calamites*, as peculiar species of these trees may have lived for a time, and thrown out their branches and leaves, before the trunks could have been prostrated. I have as yet seen only one case of a stem of *Calamites* preserved with branches, some branchlets and a few leaves attached to them, and that in the Sub-conglomerate shale of Campbell's ledge, near Pittston.

Of the 10 species described in the Coal Flora, 8 are present already in the Sub-carboniferous; two of them, limited to it; the others, distributed in the whole thickness of the Middle stage. None have been observed above or in the Permo-carboniferous.

The two species, pertaining to the American Sub-carboniferous only, or not passing above the Millstone grit, *A. gracilis*, *A. minutus*, and one described from Canada, *A. acicularis*, are, as indicated by their names, very small plants, showing an intimate degree of relation with a new species not yet described, lately discovered in the Middle Silurian of Minnesota, and mentioned already. *A. gracilis*, C. F. Pl. II, f. 4–5, and Pl. XCIII, f. 3–6, represented with its fructifications, is most common, in the Sub-carboniferous of Arkansas, Georgia, Virginia, etc., but has not been seen above, not even in the Inter-conglomerate measures.

Annularia (*annulus* ring) C. F. Pl. II, f. 1, 2, 8, 9. Plants floating, partly, at least; stems striate, articulate, with branches opposite, nearly at right angles to the articulations; leaves verticillate, connate at base by a narrow ring, lanceolate, spathulate or lingulate, obtuse, even emarginate or acuminate at apex, with a thick percurrent or excurrent medial nerve; fruits in long cylindrical spikes, with close articulations and narrowly lanceolate bracts, bearing large round sporanges in the axils of the leaves.

The species of *Annularia*, were beautiful large plants, growing in thickets, partly in water, with branches spreading all around and leaves expanded in verticills upon the surface of the water. This is apparent from the unequal length of the whorls of leaves, which are often, at least in in one species (the long-leafed *Annularia*) more elongated laterally, and toward the upper part, than on the lower side. In another species, which may be only a variety produced by immersion, the leaves are inflated, like fistulose, the medial nerve surrounded by cellular matter becoming obsolete.

Ten species of *Annularia*, are known from the American coal measures, 8 of which are in the Sub-carboniferous measures. all passing above and generally distributed, except one, which, as yet, remains peculiar to it; 2 have been found only in the upper part of the Middle carboniferous (coal M.) and 4 in the Permo-carboniferous, besides *A. carinata*, an European species of the Permian. Fragments of a small species of *Annularia*, have been discovered in the limestone of the Helderberg, (Silurian) of Michigan.

Sphenophyllum. (*Sphenos* wedge, *phyllum* leaf) C. F. Pl. II f. 6, 7,–XCI f. 6. Plants herbaceous, pinnately divided; branches inflated at the articulations; leaves verticillate, wedge-form, sessile by the narrowed base, entire on the lateral borders, crenulate, dentate, laciniate or lobate at the upper enlarged apex; medial nerve none; nervilles straight, forking once or more in ascending to the upper borders; fructifications in cylindrical spikes, with bracts curved upward in a sharp flexure from near the base.

Remains of these beautiful plants are not as abundantly distributed in the coal measures as those of *Annularia*. The leaves of each whorl are very unequal, the lower generally shorter, the upper and lateral more elongated, though sometimes they are merely spread on both sides and equal in length. The difference results from the position of the branches, either floating at the surface of the water, or totally immersed.

Twelve species of *Sphenophyllum* are described from the American coal measures. One is limited to the New River formation; 3 to the Sub-carboniferous and to the Upper measures; 4 appear in the Middle coal, of which 3 ascend to the Permo-carboniferous, which has besides, 2 new species peculiar to it.

The genus is therefore, like the preceding, of wide distribution, as are generally the aquatic plants. No stems of these plants larger than ⅜ inch have been seen; and as for *Annularia*, some of the species observed in the Sub-carboniferous are very small.

One species of *Sphenophyllum* has been obtained from the Silurian in (the Cincinnati group) and another in fine branches has been found upon granitic rocks.*

Calamostachys. (*Calamos* reed, *stachys* spike) C. F. Pl. LXXXIX f. 3–5a, XCI f. 1. are the fructifications of *Asterophyllites* already described. These spikes are seldom found in a good state of preservation and are also very rare. Of course they follow the distribution of *Asterophyllites.*

Volkmannia (a personal name) is a genus of Steinberg vaguely defined. It is made for the description of long spikes with imbricated scales, apparently covering sporanges

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*Reference is made here by Dr. Lesquereux to a specimen placed in the Museum at Cambridge, Mass., by Louis Agassiz. This remarkable object seems to be a *sphenophyllum* on a hand specimen of granite. (Private letter dated March 20, 1887, to J. P. L.)

with microspores, as seen on Pl. XC f. 4, a specimen partly broken, exposing to view the sporanges and their blades.

Macrostachya. (*Makros* long) C. F. Pl. III, f. 17–20. Large, cylindrical, oblong spikes, with bracts, imbricate, lanceolate, costate in the middle, scarcely longer than the internodes.

These spikes, analogous to those of *Volkmannia*, are considered by Schimper and some authors as the fructifications of an Equisetaceous plant with large stems, described under many different names: *Equisetum*, *Equisetites*, *Calamites*, *Asterophyllites*, etc., and which is only known by fragments, one of which is represented on Pl. III f. 14. These plants were arborescent, articulate, covered with a thin bark, plano-costate or striate; the leaves linear, carinate and nerved in the middle, acuminate, truncate when old; leaf scars marked upon the articulations by transversely oval rings like the links of a chain; scars of branches verticillate, round, umbonate, with convex central mamilla.

The description of that peculiar species is taken from Schimper, who has seen more complete parts of these plants than the fragments as yet found in this country. The spikes, like those figured in the Atlas, are common enough, especially abundant at the Cannelton mines of Pennsylvania. But the trunks were, either very rare, or fistulose and of soft tissue, as only two fragments of stems have been obtained at that locality.

LYCOPODIACEÆ.

The *Lycopodiaceæ* (club-moss family) like the Ferns and the *Calamariæ*, are cryptogamous acrogens plants, composed of woody fibres and vessels. They have a distinct axis or stem, and branches, but their subordinate characters so widely differ that they have to be considered in 3 essential sub-divisions or orders: *Lycopodites*, *Lepidodendræ* and *Sigillariæ*.

LYCOPODITES.

The plants are tufted, bushy or arborescent, dichotomous in their divisions, creeping at base or derived from creeping roots; leaves in spiral order or verticillate, all alike or biform upon the same kind of plants; fructifications in simple or bivalvate sporanges, placed in the axils of the leaves.

This definition applies also to the *Lycopodiaceæ* of the present epoch, especially distributed now in the genera *Lycopodium* and *Selaginella*, plants of small size, inhabiting mostly wet places in shady woods or humected ground. Vegetable remains of this kind are very rare in the coal measures. They have been described under the name of *Lycopodites*, found as yet only in small fragments mostly without fructification. Some of them are for that reason still of uncertain relation. We know of 14 species of them; 2 described from the Devonian of Maine; 5 from the Sub-carboniferous of Pennsylvania, 3 of which are limited to that stage, 2 passing above; and 7 distributed to the upper strata of the Middle coal measures. One of these, *Lycopodites Ortoni*, is clearly referable to the sub-genus *Selaginites*, which differs from *Lycopodites* by the leaves, which are biform and in four rows, like those of species of *Selaginella* so frequently cultivated now in our gardens. Another represents a peculiar deformation caused by the strong growth of a series of dichotomous branches (named sympodium), the branches of the 3d order appearing as laterally produced from a large stem. C. F. Pl. CVI. f. 1. No species of *Lycopodites* has been recorded from the Permo-carboniferous.

LEPIDODENDRÆ.

This section is one of the more important of the *Lycopodiaceæ*, since, with the *Sigillariæ*, it may be considered as contributing the greatest mass of woody materials to the composition of the coal.

The plants are arborescent; the leaves all of the same form, lanceolate and linear, acuminate, plano-carinate, very entire, all spirally disposed, deciduous, leaving upon the branches at their points of attachment regular scars, which, gradually enlarged by the growth of the stems, afford the only characters obtainable for the determination of the species. The trunks are formed of fascicles of vessels, mostly scalariform, united in a continuous cylinder, mixed only with parenchima. The fructifications are in catkins bearing elongated sporanges, opening laterally, attached by their base to the central axis, and horizontally supported by bracts, simple, or bearing scales or enlarged leaves at their outer end. C. F. Pl. LXIX.

The plants of this order were mostly large trees. Some trunks of *Lepidodendron* have been found measuring 100 to 130 ft. in length and 6 to 10 ft. in diameter. They were simple, or without branches up to near the summit, where they ramified into dichotomous divisions, gradually smaller and pending all around, bearing strobiles at the extremities of the branches or upon the stems. The scars of leaves very small, nearly punctiform upon the small subdivisions of the limbs, where only the leaves remain present in their fossil state, but were soon enlarged by the growth of the trees.

The genera admitted for the *Lepidodendræ* are *Lepidodendron*, *Ulodendron*, *Knorria*, *Halonia*, *Lepidophloios*; and for their separate parts, leaves, strobiles and sporanges: *Lepidostrobus*, *Macrocystis*, *Lepidocystis*, *Sporocystis*, and *Lepidophyllum*. A few other genera whose characters are less distinct: *Psilophitum*, *Leptophlœum*, and *Tæniophyllum* have also to be briefly mentioned.

Lepidodendron (*Lepis* scale, *dendron* tree.) C. Fl. Pl. LXIII–LXIV. Trees of various size, surface of the stems and branches marked by peculiar scars at the point of attachment of the leaves; leaf-scars (bolsters) rhomboidal-oblong upon the bark of the trunks of large trees, or merely rhomboidal upon the branches, very variable in size according to their position, as they become enlarged comparatively to the growth of the trees and of their branches; central cicatrices (inside scars) rhomboidal, transversely dilated, dotted by 3 points (vascular scars,) having generally, under the lower borders, two oval small tubercles (appendages) scars of bundles of vessels traversing the bark to enter the leaves, and placed on each side of a medial line more or less wrinkled across (cauda), which descends to the prolonged base of the bolsters, and which like the appendages is sometimes obsolete. C. Fl. Pl. LXIV, f. 14.

As scars of *Lepidodendron* vary according to their position upon the trees and are also subject to be disfigured by the local enlarging of the bark or by erasions, the determination of the species is difficult and demands for each the examination and comparison of numerous specimens. It has been contended that some authors have increased the number of species without sufficient reason. It may be the case, and I could not affirm that all the species admitted and described in the Coal Flora are valid and not subject to criticism. I will only say that very few, if any of those published from American specimens, have been described without the examination of a large number of specimens of different localities. For the purpose of more accuracy in ascertaining the characters, I have compared the specimens of large collections of coal plants, obtained from the Sub-carboniferous measures of Alabama, Georgia, Tennessee, Arkansas, Ohio and from the Carboniferous of Illinois, etc., especially of Pennsylvania. Mr. R. D. Lacoe, of Pittston has procured from almost all the localities where coal is worked in the United States, an immense amount of specimens, far beyond any seen even in the largest Museums of Europe, and all were put at my disposal.

In considering the distribution of the *Lepidodendra*, we may refer their first appearance to the lower Silurian, in admitting as I do, that the fragments of stems figured in Proc. Am. Phil. Soc. Vol. XVII No. 100 p. 163, and named *Protostigma Sigillarioides* (*protos* primitive, *stigma* point, impression) represent a plant related to the *Lepidodendra* or the *Sigillariæ*. It is a sub-cylindrical fragment of a branch, slightly flattened by compression, nearly 2 inches in its broadest diameter, marked with rhomboidal areoles a little enlarged transversely, placed in spiral order, having in the middle a vascular punctiform scar.

The areoles are in their position, their form, their size and the central vascular point, perfectly similar to those represented in the lower part of the stem described as *Leptophlæum*, by Prof. Dawson, from the Devonian of Maine, (Quat. Jour. Geol. Soc., London, November, 1862, p. 316, Pl. XVII, f. 53,) which the author considers as more allied to the *Lepidodendra* than to any other plant. We may see, therefore, in this fragment, a proof of the arborescent character of the *Lepidodendra*, and ascending toward the Coal measures, follow their evolution in two species of *Lepidodendron* recently discovered in the Clinton group (the upper Silurian), and by 4 species described from the Devonian. Gradually the plants of this group become more abundantly represented; for, in the Sub-carboniferous, *Lepidodendron* has 10 species proper to that formation, with 13 others which pass above into the lower strata of the Middle coal. It is there (at the base of the middle coal,) that the genus has its highest predominance; for, taking all together the species of the Sub-carboniferous with those of the Intra-conglomerate and of coal A and B above the Millstone grit, we find 29 species of *Lepidodendra* represented at that stage. Above this the genus gradually declines and loses its preponderance, until at the horizon of Coal M of the Pennsylvania section, only three of its species have been observed and none above. No species of *Lepidodendra* are mentioned in the Permo-carboniferous of West Virginia. According to Goeppert who has published the plants of the Permian of Europe, fragments of *Lepidodendra* are very rare in that formation. He describes however, as found there, *Lepidodendron Veltheimianum* (remarkably enough, for the species is generally considered as characteristic of the Lower coal measures); and some fragments of *Lepidostrobus*, the catkins or fructifications of the genus.

It is worth mentioning that not only the *Lepidodendra* but the *Lycopodiaceæ* disappear from the Carboniferous and remain unrecorded in the mesozoic ages. Even until recently no traces of *Lycopodiaceæ* had been seen in the more recent formations. It was then supposed that their reappearance at the present epoch was without connection with the ancient types.

But recently, fine species of *Selaginella* have been found in the Laramie group, (Eocene or upper Cretaceous) a formation very rich in beds of lignite, some of them of great thickness and of great value as combustible. This would indicate a peculiar affinity between these plants and the coal formation; for, species of Lycopods, one especially, the dwarf Lycopod, have their habitat upon the peat bogs of the present epoch.

Ulodendron (*Ule*, forest, *dendron* tree) C. F. Pl. LXV and LXVI. By their form, their ramification, and their size, the trees of this genus are like those of *Lepidodendron.* They are however more rarely branching, and bear, besides the leaf-scars, large, round or oval cicatrices, marked with the impressions of concentric scales, and a central mamilla. The leaf-scars are generally smaller than those of *Lepidodendron*, and their spiral distribution is often disturbed by the vertical splitting of the bark, and the protruding (outside) of the subcortical substance, producing anomalous ridges, somewhat resembling the ribs of *Sigillaria* C. F. Pl. LXV f. 3.

Some European authors unite *Ulodendron* to *Lepidodendron* in one genus. It is certain that the characters of these genera are not always persistant, and therefore seem often unreliable. The question is discussed in C. F. p. 398 etc. I still consider *Ulodendron* sufficiently distinct to be preserved as a genus.

The disposition of the species of *Ulodendron* is the same as that of *Lepidodendron.*

Knorria (proper name), C. F. Pl. LXXIV f. 14, 15. Large trees, with bark covered with elongated conical, obtuse or truncate tubercles, sometimes imbricated and in spiral order, leaving, after falling off, round convex areoles marked in the center by a single vascular scar. The leaves are long, linear, more or less inflated at the base, with a flat medial nerve.

As with *Ulodendron*, some authors, (Brongniart among them,) consider *Knorria* as a genus made of the decorticated bark of species of *Lepidodendron.* The bark of *Lepidodendron* and of the *Sigillariæ* is composed of divers layers, which by maceration become sometimes separated, like the leaves of a book. Each of these layers, of course, reproduces the scars of the vessels which traverse the bark in entering the leaves; but these scars vary in their form upon the different layers, so that the identification of different parts of the same kind of bark is sometimes obscure and uncertain. These differences are however far more marked in the *Sigillariæ* than in the *Lepidodendra*. An example of this is given in *Sigillaria monostigma*, C. Fl. Pl. LXXIII f. 3–6. According to Schimper however, this difference in the form of areoles of successive layers of bark is not remarked in *Knorria*; and if some species of *Lepidodendron* or of *Sigillaria* may show, by decortication of the upper surface, traces of elongated scars somewhat like those of *Knorria*, this does not put to naught the persistence of the characters of the genus as indicated above.

Of 4 species of *Knorria* observed in America, two are found in the Sub-conglomerate and pass to Coal A and B above the Millstone grit. One pertains to the Upper coal measures. The habitat of the fourth is uncertain.

Halonia. (*Halo* circle around the stars) C. Fl. Pl. LXI f. 1—3, 5. LXXIV f. 9. Stems of medium size, apparently creeping; cortex tuberculate and marked in the intermediate spaces by rhomboidal scars; decorticated surface covered by punctiform, round or oval papillæ, obtuse or perforated in the center and placed in spiral order.

The relations of plants of this genus are still in discussion. It is most probable that at least some species described in this genus, are creeping stems or rhizomas of *Lepidodendron*, of which the roots are still unknown. The specimens C. F. Pl. LXI f. 1 and 2, which represent the two faces of the same branch, seem to prove the truth of the supposition, as the upper part f. 1, is convex, and the tubercles are placed in the middle, or distant from the borders; while the lower surface f. 2, is nearly flat, and the tubercles placed near the borders, where the convexity is marked, and where they are out of contact with the ground. The nature of the tubercles however, and their reason of existence, remains uncertain. I consider them as adventive or undeveloped buds of branches.

Of 6 species of *Halonia* described in the Coal Flora, two are limited to the Sub-carboniferous; two inhabit the lower strata of the Middle coal measures; the horizon of the localities of two others is not ascertained.

Lepidophloios. (*Lepis* scale, *phloios* bark) C. F. Pl. LXVIII f. 1–6. The genus, as far as represented by American specimens, is known only by the bolsters upon the bark. I give here a description made by Prof. Schimper from more complete specimens. Stems aborescent, with four ranked branches disposed in spiral order; leaves coriaceous, linear, long and narrow, with a thick medial nerve, borne at base upon thick sub-erect or recurved bolsters inflated in the upper part; leaf-scars transversely rhomboidal, marked horizontally by three vascular scars, minutely papillose under the cortex. To this I may add from evidence procured by splendid American specimens, Pl. LXVIII f. 6, 7 CV f. 1, that the fructifications are in large groups of spores placed under the base of leaves apparently covering them as sporanges; a fructification very much like that of *Isotes* of the present epoch.

The transversely striated stems, known under the name of *Artisia*, woody cylinders of some trees, have been considered by some authors as referable to this genus. This would necessarily relate these plants to the Phænogamous Angiospermous plants. All the stems of that kind seen in the American coal measures have been recognized as belonging to the *Cordaiteæ*, which are examined farther on.

Nine species of *Lepidophloios* are known from the American coal measures; two, already found in the Sub-carboniferous, pass upward to the lower strata of the Middle coal, where the others are also distributed.

Lepidophyllum, *Lepidostrobus* and *Macrocystis* (*strobus* catkin, *cystis* box or sporange) are the so called genera admitted for the description and specification of the leaves, the strobiles, and the sporanges of the *Lepidodendra*. A look at plate LXIX of C. F. suffices to show that these organs, extremely varied, indicate better than any discussion on the subject, the extraordinary diversity of the characters of the *Lepidodendra*, and therefore force us to recognize as real, the many species of trees attributed to that order.

We cannot pass from the *Lepidodendra* without saying a few words of the genus *Psilophiton* established by Prof. Dawson from specimens discovered first in Canada at the very base of the Devonian and later in the middle Devonian of Maine. The stems of the plants are dichotomous, erect, foliate, sprouting from cylindrical radicles, marked by circular scars, points of insertion of the stems; leaves in spiral order, very small, merely rudimental, needleform, squamous; fructifications in naked sporanges, clavate or fusiform, placed in pairs at the extremity of terminal or axillary branchlets; young branches involute, in spiral (circinnate), as in the ferns; stems composed, like those of the *Lycopodiaceæ*, of scalariform vessels surrounded by parenchyma.

From this definition, the plants of this genus seem referable, by their circinnate development to the Ferns; and by the spiral order of the leaves and the composition of the stems, to the *Lycopodiaceæ*. The fructifications, without any marked relation to any kind of plants, have, however, from the figure given by the author, some likeness to those of the genus *Archæopteris*, a peculiar type of ferns described above, apparently the more ancient of those which came after it in Palæozoic time, and without relation to any of them.

The genus *Psilophitom* seems, therefore like a transient prototype of both the Ferns and the Lycopods; as all its representatives have been observed in the Devonian; even in the Silurian; none having reached the Sub-carboniferous. It is well to remark in regard to the circinnate unfolding of the branchlets, which would go to show a degree of analogy of *Psi ophiton* to the ferns, that the same peculiar conformation has been observed in a species of the Carboniferous, *Selaginites circinnatus* Lx. described and figured in the 2d Report of the Geol. Survey of Illinois in 1866.

Therefore, this character may be considered as a mere index of the general relation which exists between the Ferns and the Lycopodiaceæ.

SIGILLARIÆ.

Plants arborescent, trunks cylindrical, either simple or dichotomously divided at the apex, costate lengthwise or smooth, marked with scars of leaves (areoles); composed of a continuous cylindrical axis, traversed by vascular fascicles inclosing a thick medular substance, and covered by a thick solid cortex; the leaves are long, flat, linear, grass-like, biplicate and carinate, with a thick medial nerve; the points of insertion are marked by regular scars or areoles of various size and forms, ovate, oval-hexagonal, or regularly hexagonal, or transversely rhomboidal; their surface being marked with three vascular scars, the medial punctiform, the lateral sublunar; scars of the decorticated trunk generally double, oval or oblong, close to each other, varying in size, often in form, with age; fructifications in spikes, composed of sporanges inserted horizontally at the base of dilated bracts.

Of this section or order two genera, *Sigillaria* and *Stigmaria*, have to be examined.

The first question about these plants refers to the degree of affinity between the *Sigillariæ* and the *Lepidodendræ* as represented by *Sigillaria* and *Lepidodendron.*

Considering the characters perceptible to the eyes, the outside form of the trees, their leaves, their scars left upon the bark, etc., there is such an evident affinity between the two groups of plants, that one is forced to acknowledge it, and to consider them as two members or two genera of the same order.

But according to the observations made upon the structure of the trunks, by an analyses of the silicified parts of the wood, subjecting to the microscope thin slices of it made transparent by grinding, it is found by some palæobotanists that the texture of the trunks is uniform, composed of a single woody zone like that of the *Lepidodendræ;* while others see this woody part as composed of two zones, one especially, formed of striated and reticulated vessels, being *centripetal*, as its development has been made from the outside to the inside; while the outer region or woody zone, composed of the same elements, has proceeded with a growth contrary to that of the first, being therefore *centrifugal.*

The character of the wood would be, in this last case, related to that of the dichotomons angiospermous plants. French botanists maintain the last views, exposed first by Brongniart, and now by the admirable researches and publications of Renault; while the contrary assertion was sustained formerly by the English palæontologist, Binney, and more recently by Prof. Williamson of Manchester, whose works have a degree of excellence not less invaluable than those of the French authors. Deprived as we are of the means of following the same line of researches by the total absence of silicified specimens of Sigillaria and Lepidodendron (never as yet found in America) we cannot of course have a judicious opinion upon the question. But judging, as said above, from the characters appreciable by simple ocular observation, especially from the discovery of certain organs (a fructified spike of *Sigillaria*, found with fragments of the stem to which it is apparently attached) the relation of *Lepidodendron* to *Sigillaria* appears intimate; and therefore it does not seem possible to admit one of the groups as referable to the Cryptogamous plants, while the other should represent some new type of the Phænogamous. It may be however that we have here traces, by evolution, of the first modifications of internal texture in the passage of the most highly characterized type of Cryptogamous plants, to a prototype, allied to it, but having in its composition some new elements of a still higher degree of organization.

Sigillaria (*Sigilla* a little image, a seal). C. F. Pl. LXX–LXXIII. The definition of the genus is the same as that of the order, at least for the more important characters. It is only necessary for its completion to describe the radicular appendages *Stigmaria*, which merit to be examined as separate plants.

Stigmaria (*Stigma* point, impression). C. F. Pl. LXXIV f, 1–8. Roots or stems are somewhat thick, generally 2½″ to 4″ in diameter, dichotomous in their divisions which are either multiple, rapidly diminishing in size from their point of attachment to the trunk, and tending downward, then looking like roots; or horizontally expanded, sometimes very long, rarely branching, preserving the same size for long distances, cylindrical or somewhat flattened, with a central axis traversed by vascular fascicles disposed starlike; leaves or rootlets in more or less regular spiral order around the stem, leaving at their points of attachment round mamillæ, with a narrow border and a single central vascular round point. It must be remarked still, in this description, that the horizontal stems of *Stigmaria* are obtuse or forked at their extremities; and that instead of being always cylindrical, they are often seen flattened on the lower surface, with the medular axis, excentrically placed, visible under the somewhat flattened stems. This shows that the plants were either floating in water or pressed upon the mud or some soft substance. While floating the stems preserved their cylindrical form, with the medular axis central, and their leaves all around the stems; while creeping, the cellular substance of the stems with the leaves, covered only the upper surface of the medular cylinder, which remained naked underneath. This remark will help to understand not only the nature, but the purpose and the mode of vegetation of these peculiar plants.

Stigmaria were first observed a long time ago attached to the base of trees of *Sigillaria*, and therefore, have been considered for a long time, as roots. Our better knowledge of the distribution of these plants and of their peculiar characters, has set aside this idea.

The remains of *Stigmaria* are extremely common not only in the Carboniferous but in divers strata of the Palæozoic formations. Rarely seen in connection with coal, and never entirely transformed into coal, they are most abundantly found underneath a coal bed in the bottom clay, where their remains, mostly stems, more rarely leaves, are inordinately mixed together without any other kind of vegetables. They appear to have an intimate connection with these *under-clay* beds, as if they had contributed to their composition, or to the deposition of the clayey materials. More than this, these clay beds, filled with remains of *Stigmaria* only, are often thick, and isolated, or without any connection with coal beds. Strata of this kind are found from 10 to 30 feet thick, alternating with sandstone or any other kind of rocks. When hardened by compression or by metamorphism this clay is the "bastard limestone" of the miners.

Stigmaria also abounds in layers of foreign materials, especially clay, mixed with vegetable remains, interstratified as clay-partings between layers of coal. These plants have had therefore, a mode of life independent of aerial vegetation. They have or they may have lived a long time, for ages it seems, without connection with any kind of trees or other land vegetables, and therefore *they cannot be considered as roots*. For indeed, roots can not have an independent life, they are subject to the vegetation of stems, and such a subjection can not have existed during the vegetation of a plant which, as its characters evidently show, was generally immersed and which could cover with its debris immense surfaces, even to a depth of 30 feet; and that, where no traces of any other kinds of plants, no trunks, no branches, no leaves have been found.

What kind of vegetables are then these Stigmaria? Steinhauer the American first, after him Brongniart, Goeppert, Binney, Schimper, indeed most Palæontologists, have considered the question and left it unanswered; admitting generally that these plants were a kind of roots, from the fact, positively recognized, that trunks of *Sigillaria* have been found with roots attached to their base, these roots, as said above, bearing the circular areoles, and leaves also, (rather rootlets when found attached to roots.)

From long researches made on the subject, years ago, I have been led to assert that *Stigmaria* were plants of a peculiar kind, with characters of their own; and that their vegetation was independent of that of any tree; explaining of course in support of that assertion the peculiar nature of certain plants living at our epoch.

In describing the Ferns, we have seen that their inflorescence, or the act of fertilization for reproduction of the species, is not performed upon the plant-bearing stems, leaves and fructifications, but upon a separate vegetation, evolved from the germination of the seeds, and covering the ground with a texture of green filaments, named prothallium. It is upon this kind of vegetation, far different from that by which the ferns are known, that the organs of generation, (anthers and archegones) appear separately. After the process of fertilization the bud of a young plant is formed and the Prothallium disappears.

It would be possible to compare the vegetation of *Stigmaria* to that of the prothallium of the ferns and the mosses. Goeppert has made a supposition of that kind. But in *Stigmaria*, we find a real plant, woody, branching, bearing leaves or fistulose organs like leaves, serving for its growth, and at the same time sustaining it in a floating state. The difference is too marked, or the analogy too far distant.

There are some kinds of plants, now living in our swamps, which offer more appropriate points of comparison. The *Utricularиæ* (*bladderworth*,) are aquatic, immersed plants, with capillary filaments or dissected leaves, bearing little bladders, filled with air, which support and keep floating the very same kind of plants which, when sprouting upon mud or wet sand, take root and bear stems and flowers.

This mode of vegetation which is seen filling deep and wide ditches with floating filaments, living and propagating whole seasons without bearing flowers or fruiting stems, is really most similar to that indicated by the nature and characteristics of the *Stigmaria*. Their stems are supported in water or upon very soft mud by tubulose leaves, which are like the bladders full of air of *Utricularia*. Where the ground is solid a knot is formed by the connection of branches of Stigmaria, the bud of an aborescent plant appears, and instead of floating filaments, the bud takes rootlets, which, though of the same nature, become solid, inclined downwards, and the true roots of arborescent stems. That is just like a species of *Utricularia* which grows in our swamps, and which bears roots and a stem, with flowers, when growing upon wet sand, beside ditches full of water, wherein is established a vegetation of the same plant in floating filaments sustained by their bladders, and which never bear flowers, but indefinitely propagate by cuttings or ramification of their branches. In Jamaica, some epiphytes or parasitic plants grow in this way, covering vast surfaces of ground, by a kind of radicles, which, without branches or stems, expand by propagation of stolons, like those of strawberries.

Another question, which has to be examined in connection with that of the true nature of the *Stigmaria*, regards the roots of *Lepidodendron*, which as yet have not been satisfactorily observed. Some authors, Schimper among them, judging from the discovery of stigmarioid roots attached to *Sigillaria*, have supposed that the same *Stigmaria* could, in certain cases, and by different species, have become also the roots of *Lepidodendron*. If this was proved, the question of the relation of the *Lepidodendræ* and *Sigillariæ* would be definitely settled. But instead of proofs, we have as yet only hypothetical conclusions. For example, Schimper remarks that numerous trunks have been observed, in the coal mines of Europe, in their original position, with roots attached to their base: but that trunks and roots were generally so badly preserved that it had been impossible to determine to what genera they were referable, and therefore to say if the *Stigmaria* were roots of *Sigillaria* or of *Lepidodendron*.

Geinitz, a German palæontologist, says that he has recognized *Stigmaria* as being roots of *Lepidodendron rimosum*. But the specimen quoted as representing the species is decorticated, and the areoles too obscure and undeterminable. Then, too, Rich. Brown has published in the Proceed. of the Geol. Soc. of London a notice of a *Lepidodendron* with *Stigmaria* roots, representing the specimens in drawings; which led to the supposition that the trunks might belong to *Veltheimianum*, or some allied species. This also is not positive. And Schimper himself has often found abundant remains of *Stigmaria* in connection with coal strata where no *Sigillaria* were seen, but only branches and stems of *Lepidodendron*; and has observed in the Upper carboniferous of the Vosges, stems and leaves of *Stigmaria* filling whole strata, without any other vegetable remains but those of *Lepidodendron Veltheimianum* and *Knorria*. We have as yet observed nothing in the coal measures of North America which might afford reliable evidence on the subject. The fossil trunks bearing roots, found standing in Indiana, and preserved formerly in the cabinet of Prof. Dale Owen of New Harmony, have been carefully examined; and, by reason of their importance in regard to the question now treated, they have been represented with the details of the surface characters, the bark and the areoles left by the leaves. One of the trunks is figured and described C. F. p. 507 Pl. LXXIV f. 10 and 10 b. and XCII f. 11, under the name of *Didimophyllum* (*Sigillaria*)*Owenii.* As there is no doubt of the characters of these trees, we may conclude that divers kinds of trees may have been derived from *Stigmaria.* It is also remarkable that the only trunk well characterized, found in situ and bearing roots, recorded from Europe is a *Didymophyllum.* But the plants of this genus differ very little from species of *Sigillaria.*

It is certain that *Lepidodendron* has, for the support of its large trunks, either roots like those derived from the vegetation of *Stigmaria*, or a matting of small creeping stems, marked with the well known scars of *Lepidodendron.* Fragments of this last kind have been sometimes found agglomerated in the shale; but so rarely indeed, that it is not well possible to consider them as roots or supports of a kind of trees which are locally found in the greatest abundance. On another side, the strata where *Lepidodendron* is most commonly found in our coal measures, viz, the upper strata of the Sub-carboniferous measures and the lowest of the Middle coal, are those where *Stigmaria* remains are the rarest, being there generally seen only in the bottom clay of the coal beds.

There is still an unanswered question concerning the action of the *Stigmaria* in preparing or procuring the material for the formation of the impermeable bottom-clay beds of the coal. For a substratum had to be built, as foundation for the immense accumulations of vegetable remains locally heaped together to compose the combustible. In considering the relationship of coal strata to the peat deposits, it has been remarked that peat beds generally rest upon beds of soft white clay, of the same appearance and composition as that of the bottom clay beds of the

Coal measures. At the present epoch the clay beds are formed by the vegetation of water-plants totally immersed (*Confervæ*), the decomposition of which produces the muddy clay which covers the basins where the peat is formed. The *Stigmaria* do not enter into the composition of the coal; the bark of their stems, is however found sometimes in the coaly matter; but it remains there undecomposed, like hardened thin black sheets marked with areoles or scars of leaves. In the clay partings, as in the bottom clay where *Stigmaria* abounds, the stems transformed into stone or petrified, are imbedded in hardened clay of the same constitution as that of the stems. It is evident then that the plants have had, like some vegetables of the present time, the *Chara* for example, the property of assimilating silica or other elements in solution in the water, and of converting them into siliceous clay deposits. And therefore *Stigmaria* plants have contributed not only a storage for the preservation of the accumulated vegetable remains, but have apparently worked up material for certain strata of the carboniferous measures.

Botanists have found in the genus *Sigillaria* a larger number of species, 60, than in *Lepidodendron*. In order to facilitate their determination the species have been classed in 4 general sections, according to the characters, forms and position of the areoles left upon the bark of the trees. They are as follows:

1st. *Leiodermariæ*, (*leios* smooth, *derma* skin.) Surface of the trunks not costate, leaf-scars more or less distant, not contiguous. C. F. Pl. LXXIII f. 3–6, 17–21.

2d. *Clathrariæ*. (*Klethra* enclosure.) Scars contiguous by prominent borders, forming a kind of lattice upon the cortex. C. F. Pl. LXXIII f. 7–12.

3d. *Rhytidolepis*, (*rutis* wrinkle, fold, *lepis* bark, scale.) Stems more or less distinctly costate; scars discoid; vascular scars three. Pl. LXXII.

4th. *Syringodendron*. (*Syrings* a pipe, *dendron* tree.) Cortex costate, vascular scars united in one. C. F. Pl. LXX f. 1–4.

The genus *Sigillaria* is not quite as abundantly distributed as *Lepidodendron.*

Of sixty one species, two of which are placed in the subgenus *Didymophyllum*, 4 found in the Devonian, and 1 in the Pocono have not passed above. Fifteen species have been observed in the Sub-carboniferous, but of these 5 only are limited to that formation, the others being generally distributed in the measures, more abundantly in the upper strata ; the largest number, 36 in coal D to T, 9 passing to coal M and 2 in the Permo-carboniferous. Three species are persistant from the Sub-carboniferous above, being found through the whole series of the coal measures, one of them passing into the Permo-carboniferous.

Stigmaria follows the distribution of *Sigillaria.* Its species are not well defined on account of the rarely variable form of the circular scars of the leaves. One of its species is proper to the Devonian ; 1 to the Pocono ; and 1 to the Sub-carboniferous, this however not limited to it. The other species or varieties are most abundant in the upper strata of the Middle coal measures.

CORDAITEÆ.

Plants of various size, floating or arborescent, irregularly branching ; bearing, like trees, long roots tending downward; trunks formed of a large medular canal or pith, marked on the outer surface by transverse narrow parallel simple ribs, rarely joined by anastomosis, covered by a double or triple layer of wood, fascicles of spiral or scalariform vessels, passing to porous cells close to the medular canal ; leaves in spiral order, more or less distant, ribbon like, of various length and width, linear or cuneiform, subflabellate, generally gradually enlarged from the base to the middle, and also gradually narrower upward, obtuse, entire or undulate, split or obliquely truncate at the apex ; borders curving to the sessile semi-embracing or semi-lunar somewhat inflated base ; surface marked lengthwise by primary and secondary parallel simple nerves, generally more distant in the middle of the leaves, flowers in axillary racemes ; fruits of various size and shape, mostly oval.

The plants of this order were, at least for many of the species, trees of large size. A French naturalist, Grand 'Eury, (who, the first of all the palæontologists, has been able to find stems with branches, leaves and flowers attached to them, and thus to describe their characters) has seen some trees measuring at least 100 to 130 feet in length and 16 to 20 inches in diameter. The branches are oblique, the branchlets short, small, with small imbricate crowded leaves somewhat differing in form from those of the trunks. C. F. Pl. LXXVIII f. 2.

For a long time the *Cordaiteæ* were known only by fragments of their leaves; fragments very insufficient for the determination of the species, and still more so for pointing out their relations and place in the vegetable kingdom. For as the characters of these plants are derived only from their leaves and the position and arrangement of the nerves and intermediate nerviles, and as these are placed at different distances, according to the width of the leaves, which are very rarely found preserved whole, the true nature of these plants, their species, indeed their characters, have remained very uncertain until the publication of the work of Grand 'Eury in 1877. It was about the same time or in 1879 that a large number of splendid specimens of *Cordaiteæ*, branches or small trunks bearing leaves still attached to them, even flowers in racemes and mature fruits, were obtained at Cannelton, Pa. by systematic researches pursued under the direction of Mr. I. F. Mansfield, and also at Pittston by Mr. R. D. Lacoe. The specimens, together with those discovered in France, some of them being fragments of fossilized stems and fruits, which were subjected to microscopical analysis by Prof. Renauld of the Museum of Paris, have furnished quite as much light on our acquaintance with the nature and the characters of the *Cordaiteæ*, as we had had formerly on that of the *Lepidodendra*. The constitution of the woody stems, the form and nervation of the leaves, the fructifications also, relate these plants to the Phænogamous-angiosperms. They apparently represent a prototype (original type) whose ancestry remains unknown, but which finds its relation to the *Cycadeæ* and the Conifers;

especially related to the first order by the woody cylinder and pith, by the striated ribbon-like leaves, the flowers and the fruits. This at least is the opinion of Prof. Renauld, mentioned above, who has made on these plants the most careful researches.

The following genera of this order, the more important of those which have been described, demand a short examination: *Cordaites*, *Cordaianthus*, *Cordaicarpus*, *Dicranophyllum*, *Cordaistrobus*, *Desmiophyllum* and *Lepidoxylon.*

Cordaites (*Corda* personal name) C. Fl. Pl. LXXVI to LXXIX. The generic characters are those of the order, as described above.

Fragments of *Cordaites* have been found already in the strata of the Devonian, wherefrom three species have been described. Though none of the plants of which remains have been found in the Silurian, belong to this order, it is most probable that its origin is quite as ancient. In the Sub-carboniferous, the genus is already seen in numerous fragments; and five species are recorded at that stage; two of them peculiar to it; the others passing above, distributed especially in coals A, B. As said above it is in the coal of Cannelton (of which the horizon corresponds to that of coal A or B) that the largest number of remains of *Cordaites* have been found. Only one of the species ascends to coal M; and one new species is described from the Permo-carboniferous. A number of species are also recorded from the Permian of Europe.

Cordaianthus, (*anthos* flower,) the flowers of *Cordaites* C. F. Pl. LXXVI f. 4, 6. *Cordaicarpus* (*Karpos* fruit) Pl. LXXXIII f. 6–11; LXXXVI for the fruits; *Cordaistrobus* (*strobus*, catkin) Pl. LXXXII f. 3, for a cone uncertainly referred to *Cordaites*, are defined by their names and follow the geological distribution of *Cordaites*. They have been observed especially in connection with the Sub-carboniferous coal strata of Arkansas, at Campbell's ledge near Pittston, and in the coal of Cannelton. None are recorded from the higher coal measures, nor from the Permian.

Dicranophyllum Grd. 'E. (*dikranos* two pointed, *phyl-*

lum leaf) C. F. Pl. LXXXIII f. 1–3. Stems slender; leaves narrow, linear, grass-like, subcoriaceous, of various length, forking or divided in filaments at or near the apex, marked lengthwise with few primary nerves and intermediate nerviles immersed in the epidermis.

These leaves referable to the *Cordaiteæ* have been rarely found until now; their fragments have been sometimes and wrongly referred to *gramineæ*, or to monocotyledonous plants, which did not make their appearance in the vegetation of the world in Palæozoic times.

Desmiophyllum, (*desmis* bundle, leaves in fascicles.) C. F. Pl. LXXXII, f. 1. Stems slender; leaves narrow, sublinear, slightly enlarged from the base upward, single and sparse, or joined three or four together and fasciculate at their base; surface of stems and leaves irregularly ribbed lengthwise by prominent large bundles of nerves buried under the epidermis.

It is a peculiar plant which Saporta is inclined to refer to the *Salisburiæ*, but whose affinity is still uncertain.

Lepidoxylon, (*lepis* bark, *xulon* wood.) C. F. Pl. LXXXIV. The same can be said of the fragments described under this name; trunk or branches with linear leaves of various size, forking or divided upward into two or more laciniæ, very thinly nerved.

To complete the review of the vegetation of the Carboniferous epoch I shall have to briefly mention a few genera of plants whose relation to any of the groups of the Coal Flora has not been ascertained.

Idiophyllum (*idios* peculiar.) C. Fl. Pl. XXIII. f. 11. It is a remarkable leaf, probably referable to an unknown section of the Ferns. It is nearly round or somewhat kidney-shaped, entire, with a strong medial nerve pinnately divided into opposite, strong parallel branches, running at an acute angle of divergence toward the borders and crossed nearly at right angles by strong nervilles.

This leaf, found in the nodules of Mazon Creek, Ill. looks rather referable to the dicotyledonous, than to the ferns. It however can not represent a dicotyledonous, as the plants of this Class have appeared only in the Cenozoic ages or in the middle of the Cretaceous. It has a distant affinity to a kind of ferns (*Dictyophyllum*) which as yet have been found only in the lower Trias or the Jurassic.

Whittleseya Newby. (Personal name.) C. F. Pl. IV f. 1, 1a. Fronds simple or pinnate; leaflets fanlike, rounded in narrowing to the petiole, truncate, entire, crenulate or dentate at the apex; nerves in bundles of parallel filaments, converging at the base, entering the teeth of the apex and connivent at their points.

Three species have been found of this remarkable genus, both in the Sub-conglomerate measures, of northern Ohio, and of Arkansas.

These leaflets, not yet found attached to a stem or branch, have a relation to the *Salisburiæ*, a peculiar and original section of the Conifers. Another genus of the same section, *Saportea* has been described by Messrs. White and Fontaine and is represented by two species in specimens found in the Permo-carboniferous of Virginia. There, also, the same authors have found specimens of *Baiera* which pertain to the same section of the Conifers.

Tæniophyllum (*Tænia* ribbon.) C. Fl. Pl. LXXX f. 4. Stems large; leaves crowded, fistulose or flat by compression, thick, linear, decurring at base; surface smooth, bearing flakes of macrospores spread upon or superposed to the leaves apparently, or coming out from long cylindrical soranges containing them. These leaves, at first supposed to be referable to the *Cordaiteæ*, are now placed with the *Lycopodiaceæ* on account of the macrospores which they appear to contain.

Spirangium, (*speiron* envelope.) C. Fl. Pl. LXXV f. 11–15. Spindle-shaped bodies formed by bundles of narrow linear leaves? twisted in spiral, inflated in the middle, narrowed at both ends. Schimper has seen these bodies united in umbells; but as yet, and though abundantly collected in the coal measures, these bodies have always been found separated. Though obtained also in Europe more recently, and closely examined by the Palæontologists of the Museum of Paris, the nature, and therefore the affinity, of these peculiar bodies remains uncertain.

All the specimens of *Spirangium* have been found in the nodules of Mazon Creek coal A or B and in the Campbell's ledge of Pittston, intra conglomerate.

Fossil Seeds.

A large number of seeds, of different forms and sizes, have been found in the Coal measures, and described and figured C. Fl. Pl. LXXXV, CIX, CX, CXI. The seeds are generally formed of two or more layers of different compactness and hardness; and subject as they are to more or less advanced degrees of decomposition, one of their layers (*testa*) is sometimes separated from the seeds; while also, in the same state of decomposition, the seeds are generally flattened by compression; thus the original form becomes modified in various ways. This is seen in C. Fl. Pl. LXXXV f. 1, 16–34, etc., where the seeds, split vertically in the middle, show an outer envelope (*exotesta*) and a nucleus, which in f. 1. is separated by an inner narrower layer (inner or *endotesta*.) Often in small fruits as in Pl. CX f. 13, two of those layers surround the nucleus and when in this case, as in many others, the nuclei or nutlets are found free, separated from one of their testa or of both, the same kind of seeds may be preserved in *three different forms* and therefore be described under *three different names*. A number of these fossil fruits of the Coal measures have been found, in France, silicified, and therefore their inner texture can be and has been subjected to microscopical analysis. The celebrated Prof. Bronginart has figured and described a number of the fruits, using for them a new nomenclature. But as the outlines, as seen in the state of transformation into coal, or merely fossilized as we find them here, are not represented with the details of internal structure, we find no advantage for determination in comparing our figures with those published by the French author. It has been therefore advisable to follow the old classification, and to determine the fossil seeds by what we may see of their outside, though it may be casually deformed. The following divisions (so called genera) have been admitted for the description of the fossil seeds of the coal measures.

Cardiocarpus. (*kardia* the heart *karpos* fruit.) C. Fl. Pl. CIX f. 7–21, 22–25, etc. Seeds of various shape, composed of a compressed, generally cordiform or oval acute or acuminate nucleus, surrounded by a flattened fibrous border or a membranous wing, often narrowed at base into a short pedicel or appendage.

Forty species of these fruits, some of them beautifully preserved, have been described in the Coal Flora. Their distribution is peculiar; 36 of them having been obtained from the Sub and Intra-conglomerate measures, all except 8 limited to that stage. Of the whole number, a few pass above coal C, and none reach coal M.

Rhabdocarpus, (*rhabdos* striate.) C. Fl. Pl. CX f. 34–45, etc. Seeds ovate, oblong, costate or striate, surrounded by a more or less thick testa, sometimes deficient.

The species of the genus are quite as variable as those of the preceding. Twenty-five of them are described; 15 found in the Intra and Sub-carboniferous strata, but more generally distributed than the former, as 9 of them pass above, and a few of them reach coal M. One (a new species) is described from the Permo-carboniferous.

Trigonocarpus C. Fl. Pl. CX f. 51–57, CXI f. 1–15. The name indicates the essential character. The seeds are ovoid, compressed at the point of insertion, three or six costate; the ribs, more prominent toward the base, disappear sometimes above; the apex is generally pitted by a small, round or triangular cavity.

These fruits appear composed of a membranous or fibrous testa, sometimes very thick, separating in valves like a hickory nut, the nucleus being often found alone. Their characters relate them to the *Cycadeæ*.

Of the 24 species described, 10 are Sub carboniferous, 4 only pertaining to that horizon; the others are distributed in all the strata, especially in coal A to C; 3 reach coal M; but none are mentioned in the Permo-carboniferous.

Carpolithes. C. Fl. Pl. CXI, fs. 17–24. This word (fossil seed) is used for the description of seeds of peculiar or uncertain characters, which cannot enter into any of the divisions described above. The so called genus is therefore undefined, or without proper characters. Of the 20 species described, three are Devonian; 7 Sub-carboniferous, of which 6 are limited to that stage; the others are mostly found in the Lower coal, A to C. Two new species of peculiar form have been found in the Permo-carboniferous.

The seeds of the coal measures, taken all together, have in their distribution a marked affinity with *Lepidodendron* and *Sigillaria*, though their characters are in no way related to those of the *Lycopodiaceæ.*

A large number of them are apparently derived from the vegetation of the *Cordaiteæ*, of which too little is known as yet. It has been also supposed that they belonged, at least many of them, to trees not inhabiting the coal beds but living outside on dry land, either hilly or mountainous. This question is examined in the following chapter.

General Remarks on the Coal Flora.

Reviewing the composition of the Coal Flora, as briefly exposed above, one may be surprised to see that while so many species of plants have lived during the Carboniferous epoch, and have, as is asserted, contributed by their re mains to the formation of the coal, so few fragments of vegetables are recognized in the combustible matter.

The decomposition of the plants is indeed generally so complete in coal, that it is only with the assistance of a good microscope, and after submitting the bituminous matter to dissolution by some acid, that it is possible to recognize the woody fibres or fascicles of vessels which have entered into the composition of the combustible matter, and are sometimes the only remains left of the plants. In some exceptional cases, however, the fragments of vegetables, like those which are so abundantly found preserved fossil upon the roof shale of some coal beds may be clearly seen in the coaly matter itself. In coal beds of the upper measures of

Illinois thin layers of charcoal, alternating with layers of compact bituminous matter, often preserve the prints of small plants (especially ferns, with their tissue) as well as if they had been dried between sheets of paper for an herbarium ; so that the reference of these leaflets to the genera (even to the species) to which the plants belong, is easily made. Even the minutest details of the nervation are then discernible without a glass. Also, the coal of some strata in Ohio (at Nelsonsville for example) is locally mixed with such an abundance of small seeds (spores,) that specimens locally taken from the strata appear entirely composed of them. Large pieces of shale are found entirely covered with spores, without traces of any of the organs from which they are derived.

The same fact has been observed in England, where, on that account, a few naturalists have upheld the notion that coal had been entirelv made of spores ; and have offered conjectural explanations of the origin of the seeds, which are evidently macrospores or seeds of Lycopodiaceous plants. It is very easy, in looking over a number of the specimens which have been found in our Coal measures and figured in the Coal Flora, to understand their origin. For example the agglomerations of the spores of *Lepidophloios*, C. Fl. Pl. LXVIII f. 6, 7. or CV f. 1, the spore cases or sporanges of *Lepidostrobus*, ibid. Pl. LXIX f. 9–24 or CVIII f. 1, the group of spores spread upon leaves of *Tæniophyllum*, ibid. f. 3, all this and a great number of other organs which have been observed in our coal measures and which if published would have made quite a volume of great interest, show evidently how deposits of Lycopodiaceous seeds have been converted into coal by the wonderful fecundity of those plants. Nowhere as yet, have such fine and so many specimens of filled sporanges and of disseminated spores been observed as in the Carboniferous of North America.

The degree of decomposition of the plants in coal, and, therefore that of the preservation of their forms, greatly depends on peculiar circumstances helping or preventing the action of oxygen ; and also on the elements in solution, either in the water, or in the materials mixed with or superposed upon the woody deposits.

The Breckenridge Cannel coal, for example, is compact, without any traces of alternating layers; breaks with smooth fracture like marble, and generally does not show any traces of lamination. No carbonized remains of vegetables are mixed with it. Nevertheless, large fragments of *Lepidodendedron*, *Stigmaria*, or other arborscent vegetables, are met with in its compound, fossilized by the action of sulphuric acid and preserved in their natural form with their original characters perfectly distinct. The coal of that locality, as already remarked, is charged with so much bitumen, that it is dangerous to use it for steamboats on account of its burning like oil with an uncontrolable flame.

The well known cannel bed of Cannelton is made of 6 inches of bituminous laminated coal at its base, on which lies 6 to 8, sometimes 12 feet of rich cannel coal, overlaid by a bituminous shale several feet thick. The cannel coal itself has few remains of plants, on account of the vegetable matter being nearly totally decomposed. But above it, the vegetation gradually becoming less active and the water covering the debris of plants being more charged with clayey materials, the vegetable remains in process of decomposition have been partly penetrated by foreign elements, while part of their substance has become mixed with the clay as bitumen. The vegetation has been there continued under the same circumstances during a prolonged period of time, and therefore the vegetable fragments being fairly preserved, afford a fine synopsis of the Flora which has contributed to the formation of the bed of coal. No less than 250 species of plants have been determined from specimens obtained at Cannelton. There have been found large, hard, solid pieces of *Lepidodendron*, of *Lepidophloios* and their seeds; of *Sigillaria* and *Calamites;* stems bearing leaves and flowers of *Cordaites*; great branches of *Asterophyllites*, more than 20 inches long, covering a wide surface, by lateral divisions; solid pinnæ of bushy ferns of *Alethopteris*, *Neuropteris*, *Callipteridium*, etc.; together with the most delicate pinnules of *Sphenopteris*, even of the smallest species, with their fructifications. All have been preserved embedded in the same kind of a bituminous shale which, at its base, passes into coal so gradually, that it is scarcely possible to know where the combustible matter ends or the shale begins.

This mode of preservation of plants is nearly the same for the plants found in the top shale of most of the coal strata. The difference is this: with cannel coal more abundant vegetable remains are observable in the whole thickness of the strata; while in the clay beds the vegetable fragments, are less abundant, merely superficial and really petrified by the elements of the clay which penetrated the vegetable substance. In this case the Flora of the coal strata is represented by the few plants which for a short time remained living after the invasion of clayey water. In this interesting study of the plants of the roof-shales we gain a fair insight into the vegetation of the Coal measures, provided that our explorations are repeated at numerous localities and at different horizons. But the number and characters of the plants which have contributed to the composition of a single bed, cannot be computed from the vegetable remains of these top shales. They show only by a few preserved species the end of a Flora, which in its progress for long years may have been represented by hundreds of species. This is proved, not only by the plants of Cannelton, but also by the species found embedded in the nodules of a bed of clay covering the coal of Morris, Ill. The nodules have been disaggregated out of the clay and spread by the water over the bottom of Mazon Creek. From these concretions 250 species have been obtained; as many as were observed at Cannelton. But even in the generality of the coal shale, where only a few species have been discovered, the deficiency of specimens is generally due to the inadequate researches, which are usually prevented by the impossibility of closely searching the shale through its whole thickness.

It is true that some banks of shale, or rather sandstone, without coal are inhabited by very few species of plants. Under the Pittsburgh coal I have worked for hours at a bed of soft shaly sandstone full of leaves and branches of *Neu-*

ropteris hirsuta, without finding any other plant. Cases of this kind are indeed rare; and generally the continued presence of the same species found in certain strata may be satisfactorily explained. For example, the debris derived from tree ferns, or from great trees of *Lepidodendron*, or *Sigillaria*, may for years have been thrown out, and their fronds or leaves, filled there the muddy bottoms around them.

The essential characters of the plants which have entered into the composition of the coal and their distribution being known, one may inquire if the Coal Flora taken altogether is of a peculiar nature, adapted to exceptional circumstances related for example, to the existence of man, which had to come in the hereafter? Does that Flora take an eminent place in the harmony of the world, as a factor which, apparently of little importance, should attract the interest and enforce the admiration of those who look into nature and study it as the work of a Supreme Agent?

Remarkable by the simplicity and the small number of its primitive elements, the Coal Flora is not less so by the extreme diversity by which these elements become ultimately multiplied. It looks like the outgrowth of four shoots originally simple, derived from the unknown, having germinated in the darkness of Silurian ages; divided in few numbers first in Devonian times, and then later; and from the base of the Carboniferous indefinitely ramifying and growing into four immense trees, of which not only the branches, but the leaves, represent species prepared for the production of abundant materials for the composition of the coal.

The constituents of these plants are without exception woody; they thrive especially under the influence of atmospheric humidity; and, for that reason, their forms and that of their most minute subdivisions (lanceolate, needlepointed, etc.) are all appropriate for the absorption of vapors. They are all boggy plants, built to live upon soft muddy ground, and expand roots or rootlets for their support upon the surface, as do the ferns; or they grow at their base into subterranean rhizomas, which by and by solidify the ground for the support of the trees; or they divide into creeping rootstalks, prepared for the support of larger trunks; or even, provided with a peculiar auxiliary, they profit by the floating vegetation of the *Stigmaria*, which by rapid expansion of long stems and tubulose leaves, supported at the surface of the water, or of the mud, built by their multiplied crossings a net work, a solid foundation for the *Sigillariæ* and their great trunks. Even the *Cordaiteæ* have the same property of preparing the ground for aerial vegetation. They are not always arborescent; apparently some of them are small plants; or rather, their growth evidently began as floating and creeping plants, projecting in favorable circumstances small stems upwards, or growing as trees upon the support prepared by the first development of their seeds.

Under the influence of an atmosphere most favorable for an active vegetation all these plants have grown with prodigious rapidity; they have formed immense thick forests, filling basins sometimes of wide extent, sometimes small; and then have lived for ages. And what has become of them? Their debris, constantly massed in places, have formed immense accumulations, some as much as a hundred feet in thickness. Preserved against decomposition by their superposition and by superabundance of humidity, these debris have been finally immersed under water and then covered by deposits of sandy materials. Encased, so to say, for preventing their rapid decomposition by the action of the oxygen of the air, they have been gradually transformed into coal and stored up for the future use of man.

We are now warming ourselves with the caloric of the Carboniferous ages. That piece of coal which you throw into your stove or chimney is part of the Palæozoic vegetable world. Nature could not lose any of its productions, they have been carefully kept for our use.

Has the vegetation of the Coal period been limited to the low marshy places of the Carboniferous, and was it merely destined to procure and accumulate materials for the preparation of the combustible matter? Or was the surface of the earth covered at the Carboniferous time, as it is now, by different kinds of vegetation, some appropriate to marshy places, others to dry ground, flat or hilly? If we consider the records procured from periods preceding the Carboniferous, they seem to prove that, in those times, land plants were locally distributed, if not abundantly, at least in divers species and of somewhat large size.

We have from the Devonian and Catskill group:—in the *Calamariæ*, 2 *Calamites*, 1 *Sphenophyllum;* in the Ferns 14 species of *Archæopteris* with some fragments of rachis and of trunks of ferns and 1 *Sphenopteris;* in the *Lycopodiaceæ*, 2 *Lycopodites*, 3 *Lepidodendron*, 3 *Psilophiton*, 4 *Sigillaria*, 1 *Stigmaria;* in the *Cordaiteæ*, 3 *Cordaites*.

There are still recorded a few fragments of no positive relation, and of no scientific value. Of all those plants, none have been observed in the Carboniferous or in connection with beds of coal. As the number is very small, it may be admitted that the land vegetation outside of the coal formation was extremely scant, and probably limited to peculiar kinds of ground, apparently clayey. For, the more remarkable of these plants (the 14 species of *Archæopteris*) have left all their fragments in a very hard sandy shale which, originally as humected sand, may have produced these peculiar kinds of ferns. The surface of the earth was as yet without humus, and therefore the diversity of surface could not bring out a varied vegetation, the atmospheric circumstances being everywhere the same. As none of the Pre-carboniferous plants have entered into the vegetation of the coal, it is evident that for the bogs of the Carboniferous (as now for the peat bogs) the vegetation was of a peculiar character, and could in no way prosper under circumstances different from those which governed the coal swamps. And as the atmosphere was charged with a great proportion of humidity, the plants even growing out of the bogs would have followed the same mode of life as those of the swamps, and heaped their debris, continuing to live upon them; just as we see now the plants peculiar to the peat bogs growing on the slopes of the mountain, and contributing to the accumulation of the peat, provided their growth be favored by abundant humidity.

This of course would be an inference against the supposition that plants of characters different from those of the low grounds inhabited highlands of the Carboniferous. On another side, we find in the shale of the coal, or in the coal itself, as at Cannelton, fruits of peculiar characters, which cannot yet be referred to any kind of plants known in the Carboniferous. Wherefrom came these fruits, locally found in groups, thus appearing as if they had been transported by water from some land covered with a vegetation unknown to us, and therefore differing from that of the coal? Against this, we have however to say, that the number of these vegetable organisms of unknown reference is constantly lessened, by the discovery, in the Coal Flora, of new species from which the so-called foreign elements more or less evidently depend.

For years, for example, it was impossible to understand to what kind of plants the large seeds found at Cannelton could belong, until one of them was discovered attached to a branch of *Cordaites*. We may therefore believe that sooner or later all the disconnected vegetable organisms will be more positively determined, and their relation with the plants of some coal strata satisfactorily ascertained.

In Europe, however, Palæontologists mention the discovery of vegetable organs which do not seem to pertain to the Flora of the Carboniferous. I allude especially to long branching roots traversing rocks as in their natural state. Nothing like this has been observed in North America. We are thus, it seems, authorized to remark that if the domain of the Coal measures had been made beside up of, low lands, hills and mountains, these inhabited by a vegetation different from that of the plain, rivers of more or less extensive course should have traversed the low lands, and left there evident traces of their passages in ditches scooped through the coal beds or in deposits of foreign materials, pebbles especially, left in their transit.

In North America some pebbles have been found at the base of coal strata, but very rare cases of that kind have been recorded. In my explorations, pursued in the coal measures of North America for nearly 40 years, I have only once found, some pebbles filling a hole at the base of a bed of coal, near Carbondale.

These considerations might be further pursued, in trying to solve some of the vexed questions concerning the phenomena which have accompanied the deposition of coal strata. But they would be out of place in this memoir, already too long and purposed only for an examination of the characters of the Coal Flora.

INDEX.

A.

Page.

Aaron, Pittsburgh coal opened at, 312
Abers (Woods) pit, 181
Adachi, Jinzoo preparation of map, south-western Penn., by, 4
Adams, H. C., 416
Ætna Iron Works, Brush creek limestone near, 94
Aikens, Mr., section of Elk Lick coal, on lands of, 99
Albany mine, Snowden & Hogg, 349
Aleppo, Killbuck and Leet townships, Allegheny county, 100
Alequippa mine, Bailey, Wilson & Co., 192
Allegheny City and Reserve township, 97
Allegheny county, area of, 82
  “ “ geology of, 82
  “ “ rise of Pittsburgh coal in, 44
  “ river series—Lower Productive measures, 79
  “ “ synclinal, 53
Allen's, I. property, Pittsburgh coal on, 363
  “ pit, Butes' run, 359
  “ “ near Mansfield, 167
  “ run, outcrop of Pittsburgh coal on, 357
Allen township, Washington county, 243
  “ “ continuous outcrop of Pittsburgh coal in, 243
Allison air-compressor used at Laurel Hill mines, 153
Allison's mine on Chartiers Valley railroad, 218
Alps Coal Co's. mine, 346
Alpsville mine, dip of measures at, 303
  “ “ Thos. Hackett & Co., 303
American Iron and Steel Works, 160
  “ manufacturer, estimates displacement of coal by natural gas, 19
  “ mine idle owing to introduction of natural gas in 1885, 160
  “ “ Jones & Laughlin, 160
Amieville mine, J. N. Bigley, 308
  “ “ section of Pittsburgh coal at, 309
Amity mines, Jno. C. Risher, 190, 191
Amwell township Little Washington, coal mined in, 205
  “ “ Upper Washington limestone and Washington coal in, 204
Amyville colliery, drainage of, 400
Analyses, average of the Pittsburgh coal, 71
  “ of gas coal in N. Huntingdon township, 302
  “ of Waynesburg coal, 267

Page.
Anderson's pit, 369
Andrew's pit, 126,135
Annual Rep. 1885, Lincoln, Elizabeth, and Forward twps., Allegheny co., 123
Anticlinal parallel with Sewickley cr., 45
" axes of the Pittsburgh region described, 31
" just below mouth of McDowell's run, 90
" well marked at Blacksville, 45
Antrim's coal pit, 366
Apollo anticlinal, extent of, 41
" basin, a sub-division of Waynesburg synclinal, 54
Armstrong county, W. G. Platt surveys in 1878, 1
" Frank. operater of Summerhill mine, 169
" Logan & McMath's coal mined by, 111
Armstrong mine, Shaner Gas Coal Co., 307
" place, opening on Upper Freeport coal at, 315
Armstrong's, Waynesburg coal-bed at, 338
Assistance rendered, general acknowledgment of, 3
Auld, Mr., coal opened by, 133

B.

Bagdad anticlinal, Armstrong co., identification of, 37
Bailie Bros., mine, section Upper Freeport coal at, 91
Bailey, Mr., Waynesburg coal opened on land of, 274
" Wilson & Co., operators of Alequippa mine, 192
Bailey's mill, Pittsburgh coal passes under water level near, 242
Baird and McClure's, Waynesburg coal at, 275
Baldwin township, Allegheny county, 175
" " " " great limestone in region bordering, 162
" " " " Nineveh synclinal in, 175
" " " " Pittsburgh coal-bed in, 175
Baltimore and Ohio railroad constructed to Cumberland, 15
" " " " in Fayette county, 331
" " " " in Westmoreland county, 289
" " " " levels, 180
" " " " lines to lake ports, 24
" " " " Pittsburgh coal along, 179
" " " " purchase of Pittsburgh Southern R. R. by, 166
Bakerstown coal found on Brush creek, 88
" mine, 322
Banfield's pit, 221
Bank of Commerce, operating Becket's run mine, 322
Banksville, erosion of barren measures at, 162
" Pittsburgh coal at, 164
Banner Nos. 1 and 2 pits, 229
Banning's station, outcrop of Pittsburgh coal at, 351
Bares, Jas. place, area of coal near, 369
Bargedde mine, abandoned, 346
Barnard, N. section of Waynesburg coal at opening of, 256
Barney's run, Hancock's pit at mouth of, 254
Barnhart, Mr., Waynesburg coal opened on land of, 274

Page.
Barren measures at mouth of Beck's run, 160
" " coal-beds, character of, 78
" " definition of, 75
" " description of, 74
" " disintegration of dark shale at Pittsburgh in, 163
" " erosion of, at Banksville, Fairhaven, 162
" " " " " Mt. Washington, West Liberty, 162
" " exposed along Robinson's run, 147
" " exposures of, along river front, 163
" " extreme thickness exposed along the Monongahela river, 76
" " in Chartiers township, imperfect exposure of, 156
" " in German and Nicholas townships, 366
" " in N. Huntingdon township, 301
" " in Monongahela " 276
" " in Spring Hill " 370
" " in Union " 224
" " line of Fayette axis generally marked by, 49
" " largely represented in Westmoreland county, 295
" " red shales seen along branches of Saw Mill run, 162
" " red shales at Beck's station, 175
" " exposures of in Mifflin twp., 186
" " section at Cork run tunnel, 157
" " " south of Birmingham station, 163
" " " of in the vicinity of Pittsburgh, 163
" " well developed along Webster hollow, 324
" " thickness on Dunkard creek of, 76
" Barrens," the red and varigated shales at Germantown, 183
Barton coal bed description of, 79
" " " exposed near Whittset station, 351
" " " in Westmoreland co., 296
" " " seen on the Youghiogheny, 123
Baughman & Erret's, section at, 312
Bausman mine, extension of workings into Baldwin twp., 160
" " Keeling & Co., 160
Beachmont station, P. C. & Y. R. R., 148
Beadling Bros., operators of Harrison mine, 172
Beams run, outcrop on, 196
" Bearing-in " bench, Pittsburgh coal bed, 69
Bears pit, borehole put down for salt at, 254
" " on Fishpot run, 254
Beatty, Rev. Charles, visits the coal hill deposit in 1766, 5
Beatty, Rev. Jos., coal near, 112
Beatty station, Westmoreland co., 288
Beaver co., Prof. White's surveys, 1876, 1
" run in Westmoreland co., 287
Becket's run mine (Bank of Commerce), 322
Beck's run, 129
" " Barren measures at mouth of, 160
" " dividing a line between lower St. Clair and Baldwin twps., 160
" " outcrop of Pittsburgh coal bed spread by erosion of, 160
Beck's run mine, 175

Page.
“ “ “ section of Pittsburgh coal at, 176
“ station Barren measure red shales at, 175
Bedell, old pit, 181
Bedell's north and south pits, 197
Belle Vernon, glass sand opposite, 247
“ city location of, 342
“ Pittsburgh coal below, 45
Bellerophon in 4th limestone, 63
Bell House, Pittsburgh coal at, 162
Bell, Mr., coal worked on McGuire's run by, 223
Bell's Washington coal shows at, 283
“ coal, 126
“ mill, great limestone at, 311
“ “ Lisbon synclinal near, 306
Bell's J. M., pit, 134
Bell's run section of Waynesburg coal bed on, 269
Beltzhooven, Pittsburgh coal at, 36
Bellwood mine, Munhall Bros., 187
Belson's bank, section of Upper Freeport coal at, 314
“ run Upper Freeport coal on, 314
Bethel church Pittsburgh coal near, 223
Bethlehem twp., Upper Washington limestone, 204
Bevington, coal mined by Mr. Wilson, N. E. of, 212
Bigger, Mr., coal mined near Raccoon creek by, 212
Bigley, J. N., operator Amieville mine, 308
“ mine irregular drainage of, 44
Big Sewickley creek Lower Productive coal measures along, 285
“ “ “ Westmoreland co., drained by, 288
Biles, John, country pit, 244
Billingstein & McKinzies pit, 167
Birmingham Coal Co's. pit, 176
“ “ “ mines in Lower St. Clair twp., 160
“ “ “ tailropc plane used by, 395
“ shale on branches of Saw Mill run, 162
“ shales prominent in coal hill bluff, 77
“ “ imperfect exposures of Barren Measures caused by erosion of, 163
Birmingham shales in Monongahela twp., 276
Bissel mine, 322
Bitner's pit, 359
Bituminous coal fields, estimated area in Penn'a., 25
Black's bank, section at, 276
Blackburn mine, Foster, Clark & Wood, 196
Black Diamond mine, 239
“ “ “ Redstone coal near, 234
Black Hawk mine, Pittsburgh coal opened at, 362
“ “ or Driftwood mine, in Pool No. 5, 253
Blacksville, well-marked anticlinal at, 45
Blairs station, Roaring run anticlinal south of, 194
Blairsville basin, Fayette co., 333
“ coking coal basin, 329

Page.
Blairsville (Connellsville) synclinal, 57
" or Connellsville basin in Westmoreland co., 284
" Indiana axis, in Westmoreland co., 289
Block coal, Lower division Pittsburgh coal bed, sometime a, 71
Blossomville, Nineveh synclinal at, 175
Blythe mine, Youghiogheny & Ashtabula coal co., 303
Bobtown, Pittsburgh coal opened at, 281
Bolands run, outcrop of Pittsburgh coal on, 359
Bollenfield school house, section of Waynesburg coal near, 268
Bolman's pit, 237
Bower Hill, Uniontown coal at, 166
" " mines, 170
Bower's run, Spring Hill twp., Pittsburgh coal cut out by, 370
Bowles pit, 180
Bowlesby's pit, Waynesburg coal opened at, 283
Bowser, A., opening on Waynesburg coal, 256
Bowser, David, Waynesburg coal mined by, 270
Boyer's pit, 226
Boyd & Cleaver's pit, 359
Boyd, Dempster, operators at Spring Hill mine, 120
Boyd, E., opening of, 113
Boyd's mine, 357
Braddock's station, crinoidal limestone at, 164
Brady's Bend anticlinal, 33,34,35
" " " in Chartier's twp., 156
" " Dinsmore's abandoned pit on, 159
Braithwaites opening, Waynesburg coal at, 337
Brashear's bank, Waynesburg coal at, 337
Brazendale & Co's. mine, at Lucyville station, 245
Brewer, Mr., thickness of Freeport coal at bank of, 88
Briar Hill mine, Sauters & Patterson, 213
"Brick" bench Pittsburgh coal bed, 69
Bridgeville mine, A. J. Schulte & Co., 174
" " prominent soot vein at, 174
" outcrops on road near, evidently Uniontown coal bed, 166
" station, 149
" " coal opened north of, 174
" Upper St. Clair twp., 154
Bridgeport slope mine, 355
Briens pit, Upper Freeport coal mined at, 315
Brisbin's bank, section of Pittsburgh coal at, 312
Brister's, Henry, opening, 256
Brodenville, Westmoreland co., 288
Brookville axis identification of by other observers, 37
Browneller's run, Redstone coal exposed on, 351
Brown entry, section of Pittsburgh coal at, 153
Brown's Mr., mine, 103
" " Pittsburgh coal opened at, 283
Brown's run, Fayette co., 331
" " Lower Waynesburg coal bed on, 338
" " Pittsburgh coal on north fork of, 365

Page.
Brown's Son's, W. H., mine, compressed air locomotive used in, ... 398
" " " " operators of Black Diamond mine, ... 236
" " " " Saltsburg mines, system of mining at, ... 407
Brownsville, limestone I. "a" east of, ... 335
" road near 12-mile house coal opened on, ... 180
" " Redstone coal on, ... 226
" section of Sewickley coal at, ... 207
" thickness of great limestone at, ... 339
" twp., Fayette co., ... 353
" Pittsburgh coal along river near, ... 200
Brown & Co., Keystone mine, ... 118
Brush creek, N. Huntingdon twp., Pittsburgh coal along, ... 301
Brush or Grapevine ridge, ... 286,329
Brush ridge, Fayette anticlinal known as, ... 49
" " colliery purchased by Westmoreland Coal Co., ... 414
Brush run, Pittsburgh coal on, ... 298
Bryant station, Upper Freeport coal passes under water level near, . . . 95
Bryozoa, 4th limestone covered by, ... 63
Buckingham's, E., opening, section of Waynesburg coal at, ... 256
Buena Vista, Armstrong mine at, ... 307
Buffalo creek, Washington co., drained by, ... 201
" mine, ... 231,233
" twp., Little Washington coal bed in, ... 205
" " Upper Washington limestone in, ... 204
" " Washington coal mined in, ... 205
Building stone, Morgantown, S. S., quarried for, ... 98
Bulger anticlinal, ... 32
" " at Bulger station, ... 209
" " insignificant in Allegheny co., ... 127
" " in Washington co., ... 200
Bull run, crinoidal limestone on, ... 339
Burchinal's T. J., pit, Pittsburgh coal opened at, ... 371
Burd, Col. James, coal burned in 1759, by, ... 5
Burgettstown, Pittsburgh coal at, ... 212
" road great limestone on summit of, ... 212
" synclinal, ... 51,209
Burnt Cabin's summit, Pittsburgh coal at, ... 297
Burtners, thickness of Upper Freeport coal at, ... 89
Burton's opening, section of Pittsburgh coal at, ... 356
Burwell's A., land, Waynesburg coal opened on, ... 274
Bushfield's, Mr., opening, section at, ... 223
Bush run, Waynesburg coal on, ... 271
Butes run, detached area of Pittsburgh coal on, ... 359
Buzzard mine at Bairds station, ... 240

C.

Calamites in U. Waynesburg limestone, ... 63
Calamity, ... 197
Caledonia mine, T. J. Wood, ... 246
Calhoun, R., coal opened by, ... 185

Page.
Calhoun's S., pit, ... 183,185
Calley's G., house, axis of sub-basin passes near, ... 354
Calvin, Mr., Waynesburg coal opened by, ... 242
Camden mine, drainage of, ... 194
" " Geo. Lyle & Sons, ... 191
" station, P. V. & C. R. R., ... 191
Campbell Bros., New Eagle mine, ... 235
" Mr., Pittsburgh coal on land of, ... 93
Campbell's, Alex., pit, ... 141
Campbell's, coal at, ... 116,154
" Hollow, Pittsburgh coal in, ... 360
" pit, S. Fayette twp., ... 155
Camp Hill mine, D. M. Steene, ... 143
Cannon's bank, ... 104
Cannonsburg, Pittsburgh coal at, ... 37
Canton twp., U. Washington limestone exposed in, ... 204
" " Washington coal bed mined in, ... 205
Carondelet mine, ... 344
Carboniferous period, rocks in Pittsburgh region all belong to, ... 58
Carlin pit, Chartiers twp., ... 158
" rear pit, at Dinsmore's hollow, ... 158
Carlisle's, Wm., Pittsburgh coal bed at, ... 154
Carmichael's, Waynesburg bed goes under water level at, ... 275
Carnegie & Bros., Larimer, coke made by, ... 414
Carroll twp., Pittsburgh coal in, ... 233
Casteel run, Waynesburg coal above mouth of, ... 268
Castle Shannon, Baldwin twp., ... 176
" " mines located on branch from Stone House, ... 162
" " " originally opened at S. Pittsburgh, ... 161
" " " old main entry used by P. & C. S. R. R., . . . 161
Castle Shannon, Nineveh synclinal above, ... 166
" " railroad, ... 404
" " " Library village the terminus of, ... 166
Castor pit, Peter's creek, ... 198
Catsburg mine, Lewis Staib, ... 237
" " section of coal at, ... 238
Cat's run, Fayette co., ... 331
" " great limestone exposed along, ... 340
" " Pittsburgh and Sewickley coal show at mouth of, ... 364
" " Pittsburgh coal deeply cut out along, ... 367
" " mine, Ewing, Kendall & Co., ... 368
" " German twp., section of Pittsburgh coal on, ... 365
Claysville axis, ... 126
Cecil twp., Washington co., ... 213
" " U. Washington limestone in, ... 204
Cedar Hill Coal Co's. mine, ... 348
Census report of 1880 extracts from 24
Center mines, New York & Cleveland Co., ... 110
" school house, Redstone coal crops near, ... 283
" " " Sewickley coal exposed near, ... 282
" " " Waynesburg coal at, ... 269

Page.
Centerville, Pittsburgh coal exposed near, 45
“ U. Barren measure rocks at, 252
“ Waynesburg coal shows beyond, 257
Cemetery hill, greatest thickness of U. Washington limestone at, 204
Ceylon P. O., Waynesburg coal mined at, 273
Chalfant's country pit, 250
“ pit section, 117
Challanger's gas well, Mt. Pleasant twp., 217
“ pit, 216
Chamber of Commerce, Pittsburgh, report for 1884 of, 23
Champion mine, Morgan & Cunningham, 246
Channel oiling hub wheel for mine cars, drawing of, 432
Chartiers Block Coal Co., in S. Fayette twp., 147
“ “ “ “ land, Fedral Spring mine on, 148
Chartiers creek, 129, 171
“ “ chief stream in Washington co., 201
“ “ numerous openings on Pittsburgh coal along, 166
“ “ Mt. Pleasant twp., Pittsburgh coal opened along, 215
“ “ Sewickley coal on, 207
“ twp., Allegheny co., 156
“ “ Pittsburgh and Waynesburg coal in, 217
“ valley br., of P. C. & St. L. R. R., in, 202
“ “ R. R., along E. boundary of S. Fayette twp., 155
“ “ “ in Scott twp., 166
Cheat river, Fayette co., 330
“ “ in Spring Hill twp., 370
“ “ Pittsburgh coal mined by Mr. Dillner on, 281
Check-house switches, drawing of, 382
Cherry mine, Morris McCue, 145
Chestnut Hill axis, in Spring Hill twp., 370
“ “ in Westmoreland co., 285
“ Ridge anticlinal, 49, 289
“ “ “ Fayette co., 331
Christy, Andrew, 122
“ John, 122
Cincinnati mine on Houston run, 229, 231
Claridge, Manor Br. R. R., to, 289
Clarksville great limestone at, 256
“ mine, 109
“ section of Pittsburgh coal near, 272
“ Sewickley coal bed at, 256
“ Washington coal bed at, 269
“ “ “ “ “A” and “B” near, 269
Clay and slack veins, description of, 447
“ “ “ “ drawing of, 448
Claysville anticlinal, description of, 33
“ “ in Washington co., 200
“ “ at Laurel Hill mine, 152
Clever's, D., isolated areas of Pittsburgh coal at, 135
Cliff pit, 229
“ mine, Imperial Coal Co., 140

Page.

Climax mine, Lisbon sub-basin near, 361
" Coal Co's. mine, 349
Clipper mine, Clipper Coal Co., 243
Clarke, Robert W., surveys by, 12
Clugston's, Mrs., Oak Hill mine No. 4, at, 113
Coal from Pittsburgh district, yearly shipments of, 7
" not carried away by erosion, Prof. Lesley's estimates of, 67
" beds of the U. Barren measures, 62
" " " " Barren measures, value of, 78
" Bluff mine, 229,230
" Center, mining commenced in 1820 at, 7
" cutting machines, 388
" fields of the United States, area of, 25
" " " " World, area of, 25
" Hill, tunnel through, 176
" hollow, Pittsburgh coal rises to the S. E. of, 307
" lands, cost per acre of, 405
" Lick, Jefferson twp., Waynesburg coal opened at, 271
" mining first record of, 5
" Ridge mine near Espy, Washington axis at, 164
" run, N. Huntingdon twp., Pittsburgh coal along, 301
" " Pittsburgh coal at mouth of, 362
" " " " below water level on, 155
" valley, 181
" " mines, Stone Bros., 189
" " station, sandstone quarried at, 194
Cochran's country pit on branch of Thompson's run, 187
" mill, Doughty's opening opposite, 197
Coking coal fields of Fayette co., 328
Coke shipments from the Monongahela river, 22
Coleman bank, 106
" Co's. pit, section at, 136
Coleman, Hailman & Co., first coal mined for transportation by, 414
Colley's, Mr., Jollytown coal bed, identified west of, 335
Collier twp., Allegheny co., 142
" " part of, formerly incorporated in S. Fayette twp., 147
Collins, Mr., 154
Columbia mine, J. T. Jones, 324
"Commercial Gazette's" history of coal fields, quotation from, 5
Conahy's knob, section at, 93
Conemaugh or Kiskiminetas creek, 285
Conliff's, C., country pit, 109
Connecticut mine, section at, 343
Connellsville basin, entirely composed of U. Productive rocks, 286
Connellsville coke district, report published in 1876 on, 1
" sandstone in Westmoreland co., 296
" " shows at German Baptist church, Nicholson twp., 368
" " geological position of, 76
" " quarried, 188
Connellsville synclinal, description of, 57
Connelly, Mr., coal mined by, 121

Page.
Connor's, G. W., section of Waynesburg coal bed at, 273
Converson's store, 197
Cook's mill, Pittsburgh coal beneath water level at, 358
" mine, 167, 173, 222
Coon's, J. C., pits, 359
Cork run tunnel, Chartiers twp., 156
Cotton's pit, 219
Coulter's country pit, S. Fayette twp., 149
Coultersville, outcrop of Pittsburgh coal bed at, 303
Courtney mine, 231
Covode, Hon. John, President in 1854 of the Westmoreland Coal Co., 414
Cover lane, Pittsburgh ? and Little Pittsburgh beds at, 368
Cowan's bank, Carroll twp., 234
" pit, 178
Cowle & Campbell pits, Pittsburgh coal at, 360
Cox's, Mr., thickness of Waynesburg bed at, 268
Cox's, J., bank, section of Pittsburg coal bed at, 133
Crab Apple creek, Pittsburgh coal on, 356
Craft pit, 35
Crafts, Waynesburg coal at, 338
Crafton, Brady's Bend anticlinal disappears at, 156
Crawford's run, Pittsburgh coal bed on, 301, 303
Crinoidal limestone exposed along Pan Handle R. R., 156
" " coal occurring beneath at Pittsburgh, 163
" " description of, 77
" " described in Report K., 183
" " exposed below Thompson station, 183
" " " near Whittset station, 352
" " extends to Braddock's and beyond Sheridan's station, 164
" " in Hempfield twp., 313
" " on Chartiers creek, 134
" " in Reserve twp., 97
" " " Washington co., 213
" " " Westmoreland co., 296
" " section of, 157
Crombie, Skillen & Co., Venture mine, 240
Crook's, A., pit, 142
Crooked run, 280
Cross creek, in Washington co., 201, 222
" " Sewickley coal bed on, 207
" " Pittsburgh coal bed on, 200
" " twp., U. Washington limestone exposed in, 204
Crothers, Jonas, Peacock mine, 245
Crouch, Elias, Redstone and Sewickley coals on land of, 257
Crouch's pit, section at, 254
Croushour & Eisman, Pittsburgh bed opened by, 312
Crow's, A., pits, 369, 371
" mill, anticlinal at, 332
" " Fayette axis near, 370
Crowsley's pit, 173
Crowther's, Musgrave & Co., Dexter mine, 248

Page.
Croziers run, Nicholson twp., Pittsburgh coal bed along, ... 367
Culley's, J., ... 143
Cumberland twp., Greene co., ... 272
Cumming's & Co's. patent oiling hub wheel, drawing of, ... 432
" mine car wheels, description of, ... 435
Curry station, Wallace pit at, ... 181
Curry's opening on Lick run, ... 197
" pit. 116
Ctenacanthus marshii found in 4th limestone, a spine of, ... 63

D.

Dams Nos. 1 to 7 on Monongahela river, ... 12
" No. 8, " " 258
" Method of construction, ... 13
Davis Island dam, ... 11
Davistown, Waynesburg coal at, ... 283
Dawson's M., mine, section of Upper Freeport coal at, ... 89
Dean's pit, ... 350
Debalt's, Mr., opening, section of Sewickley coal at, ... 278
Dempster & Boyd, Spring Hill mine, ... 120
Dexter mine, Crowthers, Musgrave & Co., ... 248
Diamond mine, ... 169
Dickson mine, abandoned, ... 116
Diffenbaugh's pit, ... 364
Dillner, A., Pittsburgh coal mined at mouth of Cheat River by, ... 281
Dinsmore's mine, ... 154
" pit, section of Pittsburgh coal at, ... 159
Dinwiddie, Governor, ... 411
Diplodus(?) in 4th limestone, ... 63
Donegal twp., Little Washington coal bed in, ... 205
" " Upper Washington limestone in, ... 204
" " Washington coal mined in, ... 205
Douglass, Mr., thickness of Bakerstown bed at place of, ... 88
Doughty's opening, ... 197
Downer's run, crinoidal limestone well displayed on, ... 339
Drainage systems, ... 399
Dravosburg, Coal Valley mines near, ... 189
" mines opened by Jas. O'Neil, ... 190
Drinkall's, John, pit, ... 168
Dry run mine, section at, ... 236
Dunkard bed in Greene co., ... 263,266
" creek, Dunkard twp., well watered by, ... 280
" " drains southern portion of Greene co., ... 259
" " oil wells on, ... 281
" twp., Greene co., section in, ... 280
Dunlap's creek, Lower Washington limestone No. 2 on, ... 335
" " drains Fayette co., ... 330
" " Pittsburgh coal available along, ... 362
Duquesne works, N. Y. & C. Gas Coal. Co., ... 116
" " section of Pittsburgh coal at, ... 117

Page.

Duvall, Mr., Pittsburgh coal mined by, ... 250
Dynamite used in shaft sinking, ... 407

E.

East Bethlehem twp., ... 251
East Deer twp., ... 89
East Finley twp., U. Washington limestone in, ... 204
East Pike Run twp., ... 247
Eastern Allegheny, general description of, ... 101
" " Prof. Stevenson's surveys in, ... 1
" " three fourths of its area occupied by Barren measures, 83
Eclipse mine, T. S. Neel, ... 246
Eder's pit, ... 107
Edmundson's opening, ... 126
Edmundson, Wm., coal opened by, ... 135
Emitt's mine in Pine twp., ... 87
Eldersville, Washington coal at, ... 205
" section of Pittsburgh bed at, ... 223
Endless rope system of haulage, ... 397
English pit, section of Pittsburgh bed at, ... 104
Enterprise mine, mining methods at, ... 165
" " high character of coal at, ... 165
Entries, description of, ... 384
Equipment for supply slope, ... 420
Espy borough, Union twp., ... 160
Espy's forks, Pin-hook anticlinal through, ... 182
" section near, ... 194
Essen mines, Sandford & Co., ... 172
Euomphalus in 4th limestone, ... 63
Eureka mine, Stone & Co., operators, ... 320
Evans, George, Waynesburg coal on land of, ... 278
Evans mine, ... 173, 362
Everly, S., Sewickley coal opened by, ... 282
Ewing, Kendall & Co., Cat's Run mine, ... 368
Ewing & Gordon, Ewing mine, ... 145
Ewing mine, ... 145
Ewing station, Pittsburgh, bed crops out below, ... 218
Ewingsville, Pittsburgh bed at, ... 37

F.

Fairchance furnace ores identical with those at New Geneva, ... 370
" iron works, ... 331
Fairhaven, coal dipping south-east towards, ... 163
" erosion of Barren measures at, ... 162
" mine, ... 176
Fairmount synclinal identical with Allegheny river synclinal, ... 53
Fairview, Pittsburgh coal disappears near, ... 281
Fallowfield twp., Washington co., ... 240
Fans, ... 401
Fost's pit ? 372

Page.
Fost's house, Sewickley coal at, 368
Faults, description of, 451
“ drawings of, 450, 452
“ sections of coal bed near, 454
Fawcett & Co., Green Spring mines, 186
Fawn twp., Allegheny river synclinal sub-divided in, 53
Fayette anticlinal, crosses S. Huntingdon twp., 316
“ “ description of, 48
“ “ in German twp., 364
“ “ “ Nicholson twp., 366
“ “ “ Spring Hill twp, 370
“ “ Saltsburg anticlinal formerly identified with, 46
Fayette axis—Blairsville axis,
measures in Monongahela twp. affected by, 276
“ “ in Franklin and Menallen twps., 355
“ “ eastern side of Nicholson twp. occupied by, 340
Fayette co., drainage of, 330
“ “ formerly covered with U. Barren measures, 62
“ “ description of, 328
“ “ Greene co. group not identified in, 334
“ “ Prof. Stevenson's surveys in 1876 in, 1
“ “ thickness of U. Barren measures in, 63
“ “ U. Productive series in, 336
Fay's house. Pittsburgh coal near, 189
Fayetteville, section in neighborhood of, 138
Federal Spring mine, W. J. Steen, 148
Fee's, John, country bank, section at, 219
Fields', Mr., opening at Crow's Ferry, 281
Findlay twp., Allegheny co., 131
Finley's country pit, section at, 226
“ pit on Peters' creek, 198
Finleyville, limestone quarried near, 228
“ station, Pittsburgh coal opened in vicinity of, 225
Finney mine, John O'Neill, 195
Finnis St. Clair pit, 255
Fire damp, 453
Fish creek sandstone and limestone in Morgan twp., 268
Fish scales in 14th limestone, U. Barren measures, 63
Fishing creek, Pittsburgh coal bed on, 154
Fishpot limestone at Fost's house, 368
“ “ between Redstone and Sewickley coal beds, 208
“ “ description of, 73
“ “ in Greene co., 265
“ “ persistent on eastern side of the Lisbon basin, 341
“ “ Sewickley coal bed resting on, 340
“ “ in Westmoreland co., 293
“ run, Redstone and Sewickley coal beds on, 257
Fitzsimmons' house, Pittsburgh coal crosses road near, 135
“ Five-foot seam,” Sewickley coal bed known as the, 65
Flagstone quarry, Jefferson twp., 198
Flemming's country pit, 104

Page.
Flenniken's mine, Waynesburg coal mined at, ... 274
Flick, Mr., Bakerstown coal mined by, ... 88
Florence, horizon of Pittsburgh coal believed to exist at, ... 211
" section of coal east and west of, ... 211
Forsyth's, George, opening, ... 167
Fort Pitt Coal Co., Fort Pitt mines, ... 144
" " mine, ... 239
Forward twp., ... 123
" " swamps in, ... 231
Foster & Clark's mine, ... 393
Foster, Clark & Wood, Blackburn mine, ... 196
Foster Coal and Iron Co., operations at Penn station of, ... 414
" " " and Westmoreland Coal Co., consolidation of, 415
Foster pit, ... 121
" " Chartiers twp., ... 159
Foster & Handenschield pits, ... 159
Foucher's pit, ... 366
Fourteenth limestone, fish scales contained in, ... 63
Fourth axis identical with Roaring Run or Murraysville axis, ... 41
Fourth limestone, a spine of *Ctenacanthus marshii* in, ... 63
" " *Bellerophon* in, ... 63
" " covered by *Bryozoa*, ... 63
" " *Diplodus ?* in, ... 63
" " *Euomphalus* in, ... 63
" pool, mines described in, ... 251
Fox pit, section at, ... 158
Fox's new pit, ... 164
Foxtown, U. Freeport coal near, ... 316
" station, S. W. Penn. R. R., ... 314
Frain's, James pit, ... 175
Frances pit, Stickle hollow, section at, ... 352
Francis bank, section at, ... 219
Frankfort to Paris, Pittsburgh bed on road from, ... 210
Franklin church, outcrop of Pittsburgh bed near, ... 356
" twp., Fayette co., ... 355
" " geology of, ... 98
" " Little Washington coal bed in, ... 205
" " U. Washington limestone in, ... 204
" " Pittsburgh coal bed in, ... 299
" " Washington coal bed mined in, ... 205
Frazer's pit, ... 357
Frazier's opening, section at, ... 210
Freemont (old) mine, Pittsburgh coal bed opened at, ... 342
Freeport measures, outcrop on Big Sewickley creek, ... 46
" sandstone at Upper Middleton, ... 358
Fredericktown mill, ... 255
" Pittsburgh coal bed near, ... 200
" " " opened at Evans mine, ... 362
" Redstone coal at, ... 257
" Weaver's pit near, ... 255
Fritch's, L., bank, ... 135

Page.
Frosty run, Washington coal bed on, ... 280
Fry's pit on U. Freeport coal bed, ... 314
Fuller, John. Waynesburg coal bed mined at, ... 274
Fulton & Beck, opening on U. Freeport coal bed, ... 315
Fulton and Jenkintown mine, ... 311
Fulton P. O., Lisbon synclinal near, ... 306
Fulton's, Col., U. Freeport Limestone at, ... 316
Furlong & Stimmel mines, ... 346

G.

Gabler, Pittsburgh coal opened by, ... 276
Gaus, A. J., " " near, ... 371
Garard's Fort, Washington coal at, ... 283
" " Waynesburg coal at, ... 279
Garfield mine, ... 231
Garlow's pit, Pittsburgh coal at, ... 283
Garrison, A., Mifflin twp., lands of, ... 183
Garwood, Mr., Waynesburg coal opened on Telegraph road by, ... 363
Garwood's mine, Waynesburg coal bed opened at, ... 337
Gastonville, limestone quarried near, ... 228
" mine, ... 225
George's creek, area of coal near, ... 369
" " in Nicholson twp., ... 366
" " Pittsburgh coal on, ... 367
" run, drains Fayette co., ... 330
" twp., line Pittsburgh coal near, ... 365
German Baptist church, Connellsville, sandstone at, ... 368
" twp., Fayette co., ... 364
" " Lower Washington Limestone No. II in, ... 335
" " Waynesburg coal bed identified in, ... 335
Germantown, Neel's river hill works at, ... 188
Gibson's pit, ... 234
Gibsonton, Waynesburg axis crosses river at, ... 327
Gilday's smith shop, ... 190
Gillespie's, A. T., estimates on displacement of coal by natural gas, . . . 19
" mill, Pittsburgh coal exposed near, ... 223
Gillhall smith shop, section at, ... 196
Gilmore's lower pit, section, ... 173
" Mr., Waynesburg coal bed opened at, ... 336
" mine, North Webster Coal Co., ... 322
" " section of Pittsburg coal at, ... 323
" pit, section, ... 173
Glass', H., pit, ... 136
" road, Stowe twp., Pittsburgh bed on, ... 136
" sand, opposite Bellevernon, ... 347
" works opening, Pittsburgh bed opened at, ... 342
Glendale mine, section at, ... 168
Glenn opening, Catfish run, ... 180
Glenshaw, section of Upper Freeport coal at, ... 94
Globe mine Co., Globe mine, ... 248

Page.
Godshall, Charles F., 416
Goffs, Mr., Pittsburgh coal on land of, 97
Gorby's run, openings along, 250
Gordon & Ewing, Ewing mine, 145
Gorby's fork, in Washington co., 201
Gormley's abandoned pit, 158
" George, 141
" Wettingills &. country pit, 35
Gott's pit, section of Pittsburgh coal at, 317
Grable's bank, Waynesburg coal opened at, 242
Graham's, Mr., Bakestown coal on land of, 88
" pit, abandoned, 360
Grant Coal Co., Grant mine, 143
Granville, coal on Pike run near, 250
Grapeville, Little Sewickley creek rises at, 288
Grape Vine run, 178
Grassy run, Pittsburgh bed on, 372
Graver & Co.'s mines, 108
" M. mine, anticlinal west of, 38
Gravity planes, drawing of, 380
Gray & Bell's mines, 164
" " wagons used at, 391
Gray's Ferry, Pittsburgh bed near, 276
Gray's distillery, 255
" Landing, Sewickley coal at, 277
" Minor, opening, Waynesburg bed at, 278
" Pittsburgh bed at, 111
Great limestone along Chartiers Valley R. R., 171
" " and Uniontown coal, Chartiers twp., 222
" " at Boyce's station, 171
" " " Clarksville, 256
" " " Coal Valley station, 196
" " " Hoffman opening, 193
" " " head of McLaughlin's run, 180
" " " Morton summit, 191
" " " Patterson, 192
" " " Sodom, 171
" " east of Wiley P. O. cross road, 283
" " formation not massive in Fayette co., 338
" " frequently between outcrops of Pittsburgh coal, 162
" " highest rock in Hanover and Robinson twps., 210
" " in Baldwin twp., 179
" " " German twp., 365
" " " Hempfield twp., 313
" " " Nicholson twp., 368
" " " Sewickley twp., 311
" " " Upper St. Clair twp., 171
" " " Westmoreland co., 292
" " " Youghiogheny shaft, 304
" " its position and divisions, 72
" " near Cannonsburg, 222

Page.
Great limestone on summit of road near Mingo Presbyterian church, 228
“ “ “ borders of Baldwin and Scott twps., 162
“ “ Sewickley coal below the, 208
“ “ Upper division in Greene co. of, 264
“ “ well displayed in Washington twp., 339
Green crinoidal limestone near Dougherty's mill, 112
“ fossiliferous limestones, 77
“ Spring mines, section at, 187
“ “ “ T. Fawcett & Co., 186
“ “ station, 182
“ “ “ Pin Hook axis at, 186
Greenawalt hollow, coal cut out in, 307
Greene co., arrangement of twps. in, 266
“ “ coal beds in, 263
“ “ geology of, 258
“ “ group, 59,203
“ “ “ characteristic features of, 263
“ “ “ not identified in Fayette co, 334
“ “ “ wholly wanting in Westmoreland co., 290
“ “ thickness of U. Barren measures in, 63
“ “ Prof. Stevenson's surveys in, 1
“ “ surface geology of, 260
“ twp., geology of, 279
Greenfield mine, T. S. Neel, 249
Greenlee's, T., Waynesburg coal disappears at, 268
Greensboro, Birmingham shales and Morgantown sandstone near, 276
“ terraces destroyed by erosion at, 260
“ -Wiley P. O. road, Pittsburgh coal opened on, 283
Greensburg basin in Westmoreland co., 285
“ pike, coal in ravine near, 117
“ synclinal crosses R. R. at Grapeville station, 312
“ synclinal, description of, 56
“ trough, a closed basin in Hempfield twp., 311
“ “ a distinct basin, 9
“ tunnel, Greensburg synclinal crosses Penna. R. R. east of, 57
Greentree borough, available coal north of, 164
Gregg, W. H., Wood's run mine, 245
Grible's, Mr., Washington coal bed at, 335
Grimes' pit, Spring Hill twp., 370
Grover's, Mr., land, Waynesburg coal bed on, 274
Guffey gas wells on the Washington pike, 221
“ J. & W. C, Webster mine, 323
“ Jas., Pittsburgh coal at, 308
“ station, B. & O. R. R., 305
Guseman's, Mr., land, Waynesburg coal opened on, 274

H.

Hackney's pit, 366
Hall mine, 345
Haines' property, U. Freeport coal on, 313

Page.
Hamilton hollow, 184,190
Hampton twp., Allegheny co., 93
Hampton Coal Co.'s mines, 117
Hancock's pit, 254
Handel's country opening, 180
Handenschield pit, section of Pittsburgh coal at, 159
Haney's opening, Waynesburg coal at, 336
Hanlin station, opening south of, 223
Hanover twp., Washington co., 209
Hopper's bank, section at, 154
Handell's country opening, 180
Harden, O. B., preperation of map of Western Pa. by, 4
Hard's, J., place, 372
Hare, Mr., opens U. Freeport coal, 90
Harger's country opening, 180
Harlem mine, 240
Harman's creek, 201,209
Harmer twp., Allegheny co., 91
Harper's mine, 149
Harris, Isaac, list of collieries furnished by, 7
Harrison City, 389
Harrison coal-cutting machine, drawings of, 440,443
" " " used at various mines, 153,214,438
Harrison City, 298
Harrison twp., Allegheny co., 89
Harrison mine, Beadling Bros., 172
Harrison's pit, 234
Harold's, J., pit, 315
Harry's school-house, Waynesburg coal opened at, 269
Hartley & Marshall, Enterprise mine, 165,393
" " wire-rope haulage used by, 393
Hartley's mill, section of Sewickley coal at, 277
Hastings mine, section of Pittsburgh coal at, 155
Haupt, Herman, 414
Hawkins' mill, Waynesburg anticlinal near, 252
Hawkins station, elevation of Pittsburgh coal near, 116
Hawk's-nest mine, 145
Hayes, S. B., Robinson mine, 239
Hays' opening, 133
Hays' estate, Beck's run mine, 175,184
Haywood's pits, 237
Hazleton & Co., Pioneer mine, 149
Hazen's opening, section of Pittsburgh bed at, 356
Heath, Samuel, flagstone quarry, 198
Heisterberg, section of Waynesburg coal near, 363
" Washington coal bed near, 335
Hempfield extension, section of U. Washington limestone, 204
" twp., Westmoreland co., 311
Herron hill, a little coal remains in, 104
" Mr., Brush creek limestone and coal on land of, 95
Hershey's pit, 109

Page.

Heslep mine, ... 322
Hess, J., Waynesburg coal opened by, ... 242
Hews, Mr., Waynesburg coal opened by, ... 269
Hewson, Mr., section of Waynesburg coal on land of, ... 275
Hibbs, Mr., Washington coal bed traced to place of, ... 335
Hickman's pit, ... 282
Hickory village, ... 215
Hieber, Mr., U. Freeport coal at bank of, ... 94
Higbee's, elevation of Pittsburgh bed at, ... 180
Highberger's run, ... 314
Hilldale mine, ... 229,233
Hill's pit, ... 184,371
Hill's, D., house, small patch of Pittsburgh coal at, ... 359
Hyndman opening, ... 197
History and statistics of Pittsburgh region. 5
Hodgson's pit, ... 35,158
Hoffman opening, ... 197,198
Holmes pit, ... 159
Hoover, Mr., Waynesburg coal mined by, ... 336
Hopewell twp., ... 205
Hornbeck bank, ... 360
Horner's dam, Waynesburg coal exposed at, ... 275
Horse-backs and clay-veins in Rock Run mine, ... 193
Horter, Mr., Waynesburg coal opened by, ... 257
Houlsworth mill, section of Waynesburg coal at, ... 271
Houston, Mr., Waynesburg coal opened by, ... 273
Houston pit, ... 220,221
Houston school-house, section at, ... 273
Houstonville, Pittsburgh coal at, ... 220
Howard's, Henry, house, Sewickley coal at, ... 257
Huckleberry ridge, ... 48,285,286
Humphreys, A. N., assistance rendered by, ... 4
" " chapter on mining methods by, ... 411
Hunker's old carding mill, U. Freeport coal near, ... 315
Hunker station, U. Freeport coal variable at, ... 314
Hunter's, U. Freeport coal at, ... 315
Hunter's mill, Pittsburgh coal at, ... 372
Hutchins, Capt. Thomas, finds coal mines in 1760, ... 5
Hutchinson, T., Mingo mine, ... 234

I.

Imperial Coal Co., Cliff mine, ... 140
" " Montour mine, ... 138
" mine, rope-haulage system used at, ... 397
Inclined plane, drawing of, ... 418
Inclined planes, description of, ... 381,382,419
Independence twp., Washington coal workable in, ... 205
Indiana co., W. G. Platt surveyed in 1877, ... 1
" twp., ... 91
" or Blairsville anticlinal, description of, ... 47

Page.

Ingersoll rock drill, 439

Ingram station, Chartiers twp., coal at, 158

Iron City mine, Philips & Mitenzwyre, 325

Irregularities in the Pittsburgh bed, 325

Irwin basin, development of, 414

" " Lisbon synclinal in Westmoreland co. known as, 55

" pit, section of Pittsburgh bed at, 132

" station, Pittsburgh bed at, 301

Ivile mine, Jas. Jones, 238,339

J.

Jackson & McCrea banks, Pittsburgh bed opened at, 360

" Dr., connected with first survey of Pittsburgh region, 1

" Francis H., 416

Jacob's creek, area of coal near, 369

" " Fayette co., 331

" " Nicholson twp., coal on, 367

" " Westmoreland co., 284,288

" slope, 362

Jefferson, Greene co., principal point for mining Waynesburg coal, 270

" twp., Allegheny co., 194

" " Fayette co., 344

" " " " Washington coal bed identified in, 335

" " Greene co., 270

" " Washington co., 222

" " " " Washington coal bed workable in, 205

" and Washington, twp., character of Waynesburg coal bed, 336

John's opening, Pittsburgh bed at, 365

" pit, Sewickley coal bed mined at, 283

Johnson, George coal belonging to, 113

" Mr., section of Pittsburgh bed, where formerly worked by, 92

" W. E., coal at, 110

Jollytown coal bed, in Washington co., 204

" " between Casteel and Ruff's creeks, 270

" " not identified in Washington co., 290

Jones & Laughlin, American mine, 160

Jones bank, coal gas under cover near, 223

" country pit on Chartiers creek, 170

" Jas., Ivile mine, 238

" mine, back of Jones station, 198

Jumbo Coal and Coke Co.'s mines, system of mining at, 409

" " Co.'s mines, drainage at, 399

" mine, Harrison coal cutters used at, 214

" " mining methods at, 214

" T. B. Robins, 213

K.

Keasley's pit, S. Fayette twp., 148

Keeley run, Pittsburgh coal near, 362

Keeling & Co., Birmingham mine, 160

Page.
Keeling & Co., Ormsby mine, ... 160
Keener, Mr., Waynesburg coal mined by, ... 279
Kefover's, F., pit, Nicholson twp., ... 367
Kendall's, I. P., Pittsburgh coal opened at, ... 365
Kennedy station, Freeport coal group exposed near, ... 53
Keystone Coal Co.'s mine, system of working, ... 407
" mine, Brown & Co., ... 118
Kier, H. C., ... 109
Killbuck, Leet, and Aleppo twps., Allegheny co., ... 100
King's, J., pit on Lick creek, ... 180
" pit, ... 110
Kinnear & Co.'s grist mill, outcrop of Pittsburgh coal at, ... 352
Kiskiminetas creek, unnavigable, ... 11
Knight's, Mr., Waynesburg coal bed opened by, ... 363
Knob Coal Co., Knob mine, ... 252
Knob mine, method of mining at, ... 252
" " section at, ... 253
Knowlson farm, air shaft on, ... 165
Krepps' hill, U. Productive series exposed at, ... 247
" " lower portion, Washington group exposed at, ... 247
" " U. Barren measures in, ... 247

L.

Lancaster, Mr., Waynesburg coal opened by, ... 337
Lantz's, Mr., Washington coal bed at, ... 280
Larimer colliery, Nos. 1 and 2, Westmoreland Coal Co., ... 414
" Gen. W., ... 414
" mines, swamps in, ... 122
Larimer's country pit, ... 351
" station, near western limit of Lisbon basin, ... 298
Latrobe, Ligonier Valley R. R. at, ... 289
Laurel Hill, a dividing ridge in Westmoreland co., ... 284
" " anticlinal, ... 289
" " " in Fayette co., ... 331
" " mines, drainage at, ... 399
" " " methods of mining at, ... 152
" " " tail-rope system in use at, ... 395
" " " W. P. Rend & Co., ... 152
Lauterbach's pit, ... 180
Laying, Mr., Pittsburgh coal bed on lands of, ... 97
Layton station, anticlinal near, ... 332
Lawrence co., Prof. White's surveys in, ... 1
Leasdale Coal Co., Leasdale mine, ... 169
" station, Diamond mine at, ... 169
Lebanon church, Pin Hook anticlinal at, ... 182
" " Pittsburgh coal bed at, ... 191
Leechburg basin, a sub-division of Waynesburg synclinal, ... 54
Lee's mill, outcrop of Pittsburgh coal at, ... 316
" " openings at, ... 317
Leet, Aleppo & Killbuck twps., Allegheny co., ... 100

Page.
Lefever, Mr., Pittsburgh coal bed on land of, 92
Legler mine on Mingo creek, 225
" " section at, 226
Lesley, Prof. J. P., estimates the coal once existing in Penn'a., 67
" " " " extracts from paper on Pittsburgh region by, 27,28,29,60
Leslie, Mr., U. Freeport coal opened by, 90
Lesnitt country pit, 219
Lewis' pit draining Fox's mine, 158
" run, Pin Hook anticlinal crosses middle branch of, 182
Leyda's, Mr., " " " " creek at, 39,225
Library road, great limestone on, 226
" Pittsburgh coal near, 180
" village, terminus of Castle Shannon and Pitts. Southern R. R., 166
Lisbon synclinal, description of, 55
Lick creek, Snowden twp., 179
Ligonier, Ligonier Valley R. R. at. 289
" basin, composed largely of Barren measures, 286
" " Westmoreland co., 284
" synclinal. description of, 57
" valley. Prof. Stevenson's surveys in, 1
" " R. R. connects Ligionier and Latrobe. 289
Lilly, Mr., Waynesburg coal mined by, 251
Lilly's run, Lisbon eastern sub-basin on, 362
Limestone "I a" overlying Waynesburg "a" coal in Westmoreland co., 291
" No. II, (Lower Washington,) in Washington co., 205
" No. III, seems to have disappeared in Westmoreland co., 290
" No. X, (Middle Washington,) in Washington co., 204
" of the Barren measures chiefly near the top, 77
Limetown coal mining commenced in 1830 at, 7
Lincoln twp., Allegheny co., 123
Linn and Cooper's mine, section at, 146
" station, Pittsburgh coal bed goes under water near, 350
Lisbon basin, a deep trough in Fayette co., 333
" " commercial distribution of the coal in, 8
" " in Westmoreland co., 285
" (Irwin) synclinal in N. Huntingdon twp., 301
" basin, below water level in Westmoreland co., 294
" " in East Pike Run twp., 248
" " sub-divided in Jefferson twp., 345
" " U. Barren measures in, 286
" " Washington twp., wholly in the, 341
" synclinal at Port Royal, 316
" " deflection south in N. Huntingdon twp., 306
" " East Bethlehem twp., 251
" " Luzerne twp., lies wholly within the, 361
" " South Huntingdon twp., 316
" " not in Nicholson twp., 367
" trough, deeper than Blairsville basin, 330
" " passes through German twp., 364
Little Alps Coal Co's. mine, 347
" Pittsburgh coal in East Pike Run twp., 250

Page.

Little Pittsburgh coal in bore hole at Bear's pit, 254
" " " description of, 78
" " mine, 342
" Redstone " 343
" Saw Mill Run R. R., 162
" Sewickley creek, Washington co., drained by, 288
Little's, T., farm, coal opened at, 219
Little Washington coal, 203
" " " thickness of, 62
" " " wanting in Westmoreland co., 291
" " " where seen, 205
" " " wanting in Washington twp., 335
" Waynesburg coal, a black slate in Westmoreland co., 292
" " " well developed in the Lisbon trough, 338
Lobb's run, exposure of Pittsburgh coal on, 197
Lock No. 5, Pittsburgh coal at, 362
" " " Sewickley " " 257
Locks their construction described, 14
Locust Knob, 122
Lochart mine, (Peter's Creek Gas Coal and Coke Company,) 228
Locomotives used in mines, 398
Lofinks, John, country pit, 234
Logan, McMath & Armstrong, coal mined by, 111
Long run, coal mined by Mr. Robinson on, 302
" " Pittsburgh coal bed at head water of, 301
Longs pit, 359
Longenecker's Jos., pits, in Nicholson twp., 367
Lower Barren measures, called "Barrens" in some survey reports, 75
" " " thickness in Northern Allegheny of, 87
Lower bottom bench, Lower division Pittsburgh coal, description of, 70
" division Pittsburgh coal at Blythe mine, 303
" " Great limestone, used for making cement, 72
" Productive coal measures, description of, 79
" " " " elevated by Fayette anticlinal, 48
" " " " exposed along Sewickley creek, 46,285
" " " " in Spring Hill twp., 370
" " " " west of Chestnut ridge, 296
" " " " sandstones compared, 61
" Washington limestone, No. II, in Westmoreland co., 290
" " " " " " German twp., 335
" St. Clair & Baldwin R.R., Pittsburgh coal-bed along, 162
" " " twp., Allegheny county, 160
" " " Union and Pittsburgh, east of river described, 160
Lowest rocks of Fayette co., 334
Loyalhanna creek, Westmoreland co., 287
" " Greensburg basin crosses, 285
Lloyd's pit, south of Palmersville, 136
Lucyville Coal Co.'s mine, 346
" station, Brazendale & Co's mine at, 244
Luzerne twp., 361
" " Lisbon, sub-basin in, 362

Page.
Luzerne twp., Great limestone in, 339
“ “ Waynesburg coal bed available throughout, 337
“ “ “ limestone in, 338
“ “ Washington coal bed identified in, 335
Lynch's E. pit, 353
Lyon creek, Pittsburgh coal bed at, 299
Lyon's John, pit, 371
Lyon's, T., farm, Pittsburgh coal bed on, 372
Lysle & Co., the coal of old Weir farm pit, owned by, 184
Lysle & Sons, Geo., Camden mines, 191
Lyle farm, Gastonville mine on, 225
Lytle's pit, section at, 106,107

M.

Macks mill, Pittsburgh bed near, 365
“ opening, section Pittsburgh bed at, 363
Madison section, Pittsburgh bed at, 313
Magee, James, 414
Magee's pit, on McGuire's run, section at, 223
Mahoning sandstone, description of, 80
“ “ in Hempfield twp., 314
“ “ struck in bore hole at Bear's mine, 255
“ “ in Westmoreland co., 297
Main entries, plan and section showing, 374
Malone's pits, 219
Mankadick mine, Willow Grove station, 151
Manor branch railroad, extending from Manor station to Claridge, 289
“ station, 289
Mansfield Coal and Coke Co's, No. 1 mine, description of, 136
“ mine No. 2, mining methods, 167
“ Pittsburgh bed at, 51
“ synclinal, description of, 51
“ “ in Scott twp., 166
“ “ “ Southern and Western Allegheny, 125
“ “ “ South Fayette twp., 147
“ “ “ Washington co., 200
“ “ is approximately marked by Chartiers creek, 156
“ “ probably a sub-division of Nineveh synclinal, 166
Marion-Fillmore synclinal=the Greensburg synclinal in Indana co., 56
Markles, Lisbon synclinal near, 306
“ mill, Great limestone at, 292,311
Martin J. mine, thickness of Upper Freeport coal, 89
Martinsburg, Waynesburg coal bed mined near, 269
Marshall J., Pittsburgh bed on land of, 92
“ twp., Allegheny co., 87
“ William, section of Pittsburgh coal at drift of, 92
Marshall's mine, 217
Mason's pit, section at, 106
Masontown, German twp., Great limestone at, 365
“ Waynesburg coal bed exposed along road from, 336

Page.
Maple creek, Pittsburgh, bed outcrops on, 241
" Glenn bank, 254
Maples pit in West Virginia, 283
Mapletown, Monongahela twp., section at Mr. Debolt's opening, 278
McBrides A., section at, 139
McCandless twp., Allegheny co., 95
McCartney's run, coal opened on, 158
McCleary's, Cumberland twp., section at, 274
McClellandtown, Waynesburg coal bed exposed on road to, 336
McClintock Jas. coal belonging to, 122
McClure's pit on Mt. Blanc, 122
" Rev., house, coal near, 190
McClure W., Waynesburg coal bed opened by, 282
McCollough, Edmund H., 416
McConnell, Joseph, P. U. mine, 145
McConnell's, Alexander, pit, 219
" mills, coal crops out at, 219
McCormack J., section at bank of, 130
McCormack's coal, 126
" H., Pittsburgh coal at, 136
McCoy's pit, 219
McCue Morris, Cherry mine, 145
McCullough, Mr., opened coal south of Clinton, 132
McDonough's pit, 177
McDowell, Mr., Upper Freeport coal bed opened by, 90
" Nathan, 12
McDowell's run, anticlinal below the mouth of, 90
McElhaney's, Pittsburgh bed at, 181
McFarlane, Col. A. L., Brush colliery opened by, 414
McGees run, Pennsylvania railroad through valley of, 288
McGowan's pit, 226
" " section at, 194
McKane, Mr., Brush creek coal opened on land of, 100
McKees, Mrs., house, swamp near, 195
" John, coal disappearing at, 179
" W., coal crops opposite, 141
" pit on Streets run, Pittsburgh bed first opened at, 183
" " section at, 183
McKeesport, Neel's coal works opposite, 188
McKelvey farm, opening on, 116
McKenzie's, Billingstien and pit, 107
McKinley, connected with First Geological Survey of Pittsburgh region, 1
McKinney, " " " " " " ". 1
McLaren, W., section of coal mined by, 144
McLaughlin's run, Great limestone at head of, 180
McLeans gas well, Pittsburgh coal struck in, 217
McMahon's Hugh, bank below Bellevernon, 241
McMillan's, Andrew, section of Pittsburgh coal at, 173
" coal bank, Washington anticlinal near, 171,125
" mine, 37
Mellon Bros., coal on lands of, 110

Page.

Menallen twp., Fayette co., ... 355
Menonite church, Pittsburgh bed at, ... 365
Merchant mine, David Bowden, ... 347
Merediths, John, pit, ... 219
Merrittstown, Waynesburg coal below water level at, ... 363
Methods of mining, ... 437
Method of mine working, Page plate showing, ... 386
Mevey's, S. P., country pit, ... 142
Meyer's, Mrs., Little Freeport coal bed in creek near, ... 94
Michaels pit, ... 120
Micheners mine, section at, ... 250
Middletown road, outcrop in Stowe twp., along, ... 135
Middle Washington limestone exposed in Jefferson twp., ... 222
Midway mine, ... 216
Mifflin twp., Allegheny co., ... 181
Miller's, A., old house section of coal at, ... 185
“ Pittsburgh coal at, ... 111
“ coal in North Versailles twp., ... 43
“ country pit, section at, ... 218
“ creek, Pittsburgh bed on, ... 154
“ I., outcrop at, ... 120
“ Mr., Pittsburgh bed opened at, ... 283
“ opening, thickness of Upper Freeport coal at, ... 94
“ run, Upper Barren measures show on, ... 215
Millerstown, Brush creek coal near, ... 90
Millhollands store, Uniontown coal bed at, ... 166
Millsboro', Pittsburgh bed outcrop opposite, ... 362
“ “ “ at, ... 255
“ Redstone coal at, ... 257
Mine cars, description of, ... 435
“ “ drawing of, ... 426
“ car hitchings, drawing of, ... 434
“ employés and wages of, ... 403
“ locomotives, ... 398
“ wagons, drawing of, ... 390
Mineral run branch, coal on, ... 197
Miners' pay for entry driving, ... 441
“ tools, ... 436
Mining in Upper Freeport bed in Hempfield twp., ... 314
“ machines, ... 438
“ methods in Pittsburgh coal region, ... 373
Mingo creek, Legler mine on, ... 225
“ mine T. Hutchinson, ... 234
Minor's opening near Jefferson, ... 271
“ Sam'l., opening Waynesburg coal at, ... 279
Mohawk school house, exposure of coal at, ... 154
Monaghans pit, ... 369
Monongahela City sub-axis, coal rising to, ... 231
“ Navigation Co., extracts from the History of, ... 13
“ “ Co's. first locks constructed, ... 7
“ “ “ make surveys in 1838, ... 12

Page.
Monongahela Navigation Co's. river facilities, ... 322
" " " table of coal shipments by, ... 17
Monongahela river, drains western Fayette co., ... 330
" " Pin Hook anticlinal through, ... 182
" " series, well exposed south of Greensborough, ... 264
" " " in Washington co., ... 206
" " " named by Prof. Rogers, ... 64
" " system of slack water dams along, ... 11
" shore line railroad, ... 321
" twp., Greene co., ... 276
Monroeville, coal near, ... 113
Montour mine, Imperial Coal Co., ... 138
Montours Run railroad, a local road, ... 137
" run, ... 129
Montgomerys pit, section at, ... 255
Moon twp., Allegheny co., ... 130
Morgan twp., Greene co., ... 268
" & Cunningham, Champion mine, ... 246
Morgantown sandstone and shales at Camden mines, ... 191
" " at Neel's workings, ... 188
" " on branches of Saw Mill run, ... 162
" " well exposed near Whittset station, ... 351
" " in Monongahela twp., ... 276
" " in Sewickley twp., ... 305
" " in Webster hollow, ... 324
" " in Westmoreland co., ... 296
" " quarried for building stone, ... 98
" " in bore hole at Bear's pit, ... 255
Morris cross roads, Fayette axis west of, ... 370
" twp., Upper Washington limestone in, ... 204
" " Washington coal mined in, ... 205
Morrow's, Henry, coal at, ... 110
Morton place, summit at, ... 182
" summit, ... 191
Mt. Lebanon coal bed, probably Uniontown coal bed, ... 166
" " Pittsburgh bed at, ... 185
" Pleasant twp., Washington co., ... 215
" " " Upper Washington limestone in, ... 204
" " " Washington coal bed workable in, ... 205
" Washington, ... 176
" " erosion of Barren measures at, ... 162
Muddy creek, fine terrace at mouth of, ... 260
" run, in Cumberland twp., ... 259
" " Lisbon synclinal at mouth of, ... 361
Munhall station, ... 187
Murphy's pit, Washington co., ... 225
" " Fayette co, ... 357
Murraysville anticlinal, probably in Union twp., ... 224
" " crosses Penn'a. railroad, ... 301
" " =Roaring Run anticlinal, ... 41
" " in Westmoreland co., ... 285
" " sinking along Allegheny county line, ... 231

N.

Page.

National pike, Upper Barren measures on, ... 252
" " Upper Washington limestone north of, ... 334
" coal works at Noblestown station, ... 150
Natural gas, Bellevernon glass works using, ... 342
" " displaces coal, ... 19
" " its development upon the anticlinal theory, ... 44
" " " effect upon the coal industry, ... 18
Navigation, extent and perfection in Pittsburgh region of, ... 11
" in Greene co., ... 258
Neel mines abandoned, ... 188
" & Oliver, ... 188
" coal works, Beehive coke used at, ... 188
" " " section at, ... 189
" Col. John, country pit on property of, ... 188
" T. S.. Eclipse mine, ... 246
" " Greenfield mine, ... 249
Neely, Miss, Pittsburgh coal in Ross twp. on land of, ... 97
Neuropteris in Upper Washington limestone, ... 63
Newcomer's, Fayette anticlinal at, ... 364
" opening, section at, ... 365
New Eagle mine, Campbell Bros., ... 235,236
New Geneva, Pittsburgh coal at, ... 369
" " Sewickley coal bed near, ... 370
" Hill workings, ... 319
" Salem cross roads, Pittsburgh bed at, ... 361
" " Pittsburgh bed outcrops east of, ... 361
" " Redstone coal near, ... 293
" school house, North Fayette twp., ... 142
" Texas road, Plum twp., section near, ... 111
Newtown and Murraysville road crossed by Lisbon basin, ... 299
New Tremont mine, John A. Wood & Son, ... 343
New York and Cleveland Gas Coal Co., ... 107
" " " " mine, ... 410
" " " " mine No. 2, "Centre mine," . . 110
" " " " mine in Penn twp, ... 106
Nichols bank, ... 358
Nicholson twp., Fayette co., ... 366
" " development of Sewickley coal in, ... 340
" " Fayette anticlinal enters, ... 48
Nimick station in Chartiers twp., ... 156
Nineveh coal bed in Greene co., ... 263,266
" synclinal, ... 52,161,177
" " in Baldwin twp., ... 175
" " in line with school house No. 7, ... 180
" " in Washington co., ... 200
" " sub-division marked by Streets run, ... 182
" " touches south-east corner of Scott twp., ... 166
Nixon mine at Leasdale, ... 168
Noble's, Mr., Waynesburg coal bed at, ... 275

Page.

Noblestown, 150
Nolte, Mr., section of Pittsburgh bed at bank of, 131
Norcross opening, Waynesburg coal bed at, 337
North and South Versailles twps., Allegheny co., 118
North fork in Washington, 256
" " principal tributary of Chartiers creek, 201
" Fayette twp., Allegheny co., 137
" Huntingdon twp., Westmoreland co., 300
" " " analysis of gas coal from, 302
" " " western side of Lisbon basin in, 299
" Mansfield station on Pan handle railroad, 156
" Side colliery, 414
" star, 212
" Strabane twp., Little Washington coal in, 205
" Webster Coal Co., 322
Northern Allegheny co., geology of, 84
Norwalk compressor, description of, 443
" compressors used at Jumbo mine, 214
Nottingham mines Nos. 1 and 2, 227
" road, exposure of Waynesburg coal on, 250
" twp., Upper Washington limestone in, 204

O.

Oakdale station, Pittsburgh bed eroded near, 150
Oak Hill colliery, drawing of workings at, 408
" " No 3 mine, N. Y. & C. Gas Coal Co., 114,117
" " No. 4 mine, description of, 113
" Ridge mine, 149
Ocean mine No. 1, Youghiogheny River Coal Co., 307
Ogilvie's pit, 357
O'Hara twp., Allegheny co., 91
Ohio " " " 99
Oil and gas well records, depth to Pittsburgh coal, 30
Old Hill workings, 319
Old mines used for cellars, 345
Old Scotch Hill mine, now Robins & Jenkins', 303
Oliphant, F. H., Jr., furnishes Youghiogheny shaft record, 304
O'Neil, Jas., opened Dravosburg mines, 190
" John, Finney and Pine Run mines, 195
Ormsby mine, Keeling & Co., 160
" " mining methods at, 161
" " station, American mine near, 160
Orr, S. C., Waynesburg coal opened by, 269
Osceola colliery, Westmoreland Coal Co., 415
" mine, 122,304
" station, openings on Pittsburgh bed at, 303
Overholtzer's pit, 119

P.

Page.
Page plates. Check house and switches, 382
" " Clay veins, 448
" " Equipment of supply slope, 420
" " Faults in Pittsburgh coal bed, 450,452
" " Gravity planes, 380
" " Harrison on coal-cutting machine, 440
" " " " " in operation, 442
" " Inclined plane, 418
" " Laurel Hill mines, Tail engine plan, 396
" " Main entries, plan and section, 374
" " Method of Mine working, 386
" " Mine wagons, 390,426
" " " " details, 428
" " " " hitchings, 434
" " " " wheels, 432
" " Miner's tools, 436
" " Oak Hill colliery workings, 408
" " Railroad tipple, 376
" " River tipple and incline, 378
" " Rope-haulage at Larimer colliery, details, 430
" " Sections of coal bed near fault, 454
" " Truck and bucket, 422
" " Ventilating furnace, 402
" " Wallace Automatic water elevator, 444
Painter opening, 317
Painter run, Jones county pit at mouth of, 170
Painter's salt works, opening on U. Freeport coal, 314
Painterville, U. Freeport coal at, 314
Pan-handle R. R., 147,149,200,202
Paris, Pittsburgh coal near, 210
Parker, Mr., Waynesburg coal bed opened by, 273
Parkhill's mill, Little Waynesburg bed near, 338
" " Great limestone near, 339
" " road, Washington coal bed on, 335
Parshall's E., Pittsburgh bed opened by, 365,368
Patterson's hollow, 184
" pit, 184
" summit, 192
Patton twp., 112
Pucketa creek, section of Pittsburgh coal on, 112
Paxton's pit, 219
Paynetown mine, 322
Peacock mine, 245
Penna Coal Co's mine, section at, 302
Penn Gas Coal Co., fault through collieries of, 451
" " " " mines, 301,309,310,312
" " " " new method of driving rooms, 438
" " " " Sewickley R. R., operated by, 289
Penn, John, Governor, land titles in new purchase, 411

Page.
Pennsylvania R. R., elevation of Pittsburgh bed on, ... 55
" " " roads operated by, ... 23
" " " built to Pittsburgh in 1852, ... 15
Penn township, Allegheny co., ... 105
Perry township, Fayette co., ... 350
" " Redstone coal bed in, ... 341
Perrysville axis, sub-divides Lisbon basin, ... 55
Perryoplis road, Great limestone on,. 339
Peter's creek axis identical with Roaring run axis, ... 41
" " cuts into Barren measures, ... 181
" " Pittsburgh coal crops out along, ... 224
" " Gas Coal and Coke Co., ... 228
Peters, J., coal opened by, ... 236
Peters twp., Upper Washington limestone in, ... 204
Philadelphia Youghiogheny Coal Co., ... 415
Philips & Mitenzwyre, Iron city mine, ... 325
Phillips coal opening, ... 126,227,359
" John, county bank, ... 135
" Mrs., pit, ... 255
" William, outcrop of Pittsburgh bed at, ... 135
Phœnix mine, ... 35,159
Piedmont sandstone in bore hole at Bear's mine, ... 255
Pierce pit on Peters creek, ... 198
Pierce's, Dr., Pittsburgh bed outcrops near, ... 198
Piersal's pit, ... 357
Pigeon creek, ... 200
Pike run openings, ... 247,250
Pin-hook, section of Waynesburg coal at, ... 206,207
" anticlinal, description of, ... 37
" " elevation of Pittsburgh bed on, ... 124
" section in Jefferson twp., ... 194
" " " Mifflin twp., ... 181
" " " Nottingham twp., ... 225
" " " Penn twp., ... 105
" " " Peters twp., ... 225
" " " Southern Allegheny co., ... 124
" " " Snowden twp., ... 179
" " " Union twp., ... 224
" " " Washington co., ... 200
Pine creek limestone, ... 95
Pine run, lowest limestone exposed on, ... 194
" " mine, ... 195
" " twp., Allegheny co., ... 87
Pioneer mine, ... 149
Pit car irons drawing of, ... 428
Pittsburgh, description of, ... 10
" estimate of railroad tonnage of, ... 25
" first coal shipped from, ... 7
" increase of population, ... 102
" natural transportation facilities, ... 11
" steamboats, ... 22

Page.
Pittsburgh & Castle Shannon R. R., 160
“ & Chicago Gas Coal Co's. mines, 181,225
“ & Lake Erie R. R., 289,331
“ coal bed average analysis of, 71
“ “ “ description of, 67
“ “ “ denuded east of Blairsville basin, 329
“ “ “ its thickness, position and character, 25
“ “ “ its rise north-eastward through Allegheny co., 44
“ “ “ its regularity and persistency, 31,64
“ “ “ limits of, 67
“ “ “ table of variation in thickness of, 70
“ “ “ special attention directed to, 3
“ “ “ typical section of, 446
“ “ “ the region owes its preeminence to, 10
“ “ “ used for manufacturing gas, 26
“ “ region, mining methods in, 373
“ “ “ structural features of, 30
“ “ “ what is known as the, 8,9
Pittsburgh, Chartiers & Youghiogheny R. R., 166,172
“ limestone at New Tremont mine, 343
“ lower sandstone, good exposures of, 171
“ sandstone, quarried, 221
“ “ upper, 162,168
“ series = Barren measures, 75,208,265
“ Southern R. R., 166
“ Virginia & Charleston R. R., 194,202
Pisgah summit, 365
Platt, W. G., surveys by, 1
Plum creek mines, 54,109
“ “ Waynesburg coal on, 256
“ run, Thompson's pit on, 220
“ twp., Allegheny co., 110
Plummer, Mr., coal opened by, 223
Point Marion, 370
Point View hotel, 175
Pollock's run, Waynesburg anticlinal on, 306
Pool Nos. 1, 2, 3, 4, 20
“ “ 5, 17
Population of Fayette co., 328
Port Perry mine, 121
Port Royal Coal & Coke Co., shafts, 318
“ “ Lisbon synclinal at, 316
Potter's, Henry, pit, section at, 180
Poundstones, Mr., Pittsburgh and Sewickley beds on property of, 364
Powers, Mr., Smith mine, 149
Powers' pit, 121
Price, Mr., Waynesburg coal opened by, 270,337
Primrose mine, 215
Proportion of sizes of coal produced, 419
Prospecting in Pittsburgh region, 373
Pucketa creek, elevations on, 112
Pugh, Mr., section of Upper Freeport coal, opened by, 90

Q.

Page.

Quarries, numerous in Collier twp., 145
Quarry of Morgantown? sandstone in North Fayette twp., 141
“ opposite Brinton station, 122

R.

Raccoon creek, coal mined by Mr. Bigger on, 212
“ “ Washington co., 209
Rainbow mine, Whittset station, 352
Railroad cars, 455
Rails used at mines, 375
Railway system of Pittsburgh region, 23
Ramsey's, Mr., Pittsburgh bed on land of, 97
Rankin's country pit, 226
“ school house, Washington coal at, 215
Rath pit, 193
Ray's, J., house, Great limestone quarried at, 198
Redds', Mr., house, Redstone and Sewickley coal near, 241
“ Thos., bank, 241
Redstone branch R. R., 331
“ coal bed, 228
“ “ “ at Hoffman opening, 198
“ “ “ at Smithton, 330
“ “ “ at Morton's summit, 191
“ “ “ in Brownsville twp., 335
“ “ “ crops near Centre school house, 283
“ “ “ description of, 66
“ “ “ exposed along river, 347
“ “ “ “ at Linn station, 350
“ “ “ extent of, 66
“ “ “ horizon of Knob mine, 252
“ “ “ in Baldwin twp., 179
“ “ “ “ Greene co., 265
“ “ “ “ Hempfield twp., 313
“ “ “ “ Luzerne twp., 363
“ “ “ “ Mifflin twp., 183
“ “ “ “ Monongahela twp., 277
“ “ “ “ Nicholson twp., 367
“ “ “ “ Sewickley twp., 311
“ “ “ “ Spring Hill twp., 370
“ “ “ “ Youghiogheny shaft, 305
“ “ “ near Challenger's gas mill, 217
“ “ “ “ Legler mine, 226
“ “ “ opened near Fayette city, 343
“ “ “ persistent throughout the Lisbon basin, 343
“ “ “ Westmoreland co., 207,291
“ creek drains Fayette co., 330
“ “ Upper Freeport coal on, 49
“ limestone, character of, 341

Page.
Redstone P. O , Fayette axis passes, 333
" twp., limestone No. III in, 335
" " Washington coal bed in, 335
" " Waynesburg coal bed in, 337
Red Store, Pittsburgh coal near, 168
Reed mine, abandoned, 249
Register & Martin's pit, 255
Reiley's pit, 179
Remington, outcrop at, 127, 136
Rend & Co., W. P., Laurel Hill mines, 152
" mine, coal-cutting machines used at, 338
Report for 1885, Roaring Run or Murraysville anticlinal, 41
" K, Barren measures referred to in, 213
" " Waynesburg synclinal, 55
" " section between Pittsburgh and Uniontown coal beds, from, 249
" " " of Upper Productive measures from, 247
" KK, Youghiogheny shaft record from, 304
Republic mine, Republic Coal Co., 309
Reserve twp. and city of Allegheny, 97
Rex's openings, sections of Waynesburg coal at, 270
Risher, John C., Amity mine, 191
River interests, 11
Rhizodus in 3d limestone, 63
Rhodes opening in S. Huntingdon twp., 317
Richland twp., Allegheny co., 88
Ridge road, limestone on, 172
Risher's, I. D., new works, 184
" new railroad, 185
River trade mostly confined to the first four pools, 8
Roaring Run anticlinal in Jefferson twp., 194
" " " " Allegheny co., 124
" " = Murraysville axis, 41, 188
Robbins & Jenkins mine, 303
Robbs, John, coal at, 141
Robertson, A., bank, section of Pittsburgh bed, 317
" " house, Pittsburgh crops at, 316
Roberts, W. Milnor, charge of surveys for Monongahela Navigation Co., 12
Robeson creek, Pittsburgh bed on, 215
" twp., Washington co., 209
" Pittsburgh coal eroded from northern half of, 212
Robins, T. B., Willow Grove mines, 151
" " Jumbo mine, 213
" " Primrose mine, 215
Robinson creek, 129
" fork in Washington co., 201
" mine, S. B. Hayes, 239
" Mr., Long Run coal mined by, 302
" Run church, old workings at, 151
" twp., Allegheny co., 133
Rock Run mine, W. J. Snodgrass, 193
" " station, Jefferson twp., 195

Page.
Rodenbaugh's, Mrs., Pittsburgh bed on land of, ... 97
Rogers', D. W., Waynesburg coal at, ... 267
" Prof., nomenclature by, ... 64,79
Rolling stock used in Pittsburgh region, ... 389
Roof division of Pittsburgh bed described, ...68,69
Ropes used on planes, ... 384
Rosedale P. O., Sewickley coal at, ... 283
Ross twp., Allegheny co., ... 96
Rostraver mine, Mr. Schrader, ... 326
" P. O., area of Upper Barren measures at, ... 327
" twp., Westmoreland co , ... 320
" " Redstone coal mined in, ... 293
Ruff's creek, several openings on, ... 264

S.

Sacketts pit, ... 370
Salem, Pittsburgh bed crops at, ... 297
" twp., coal in. 300
Salt Lick run, Pittsburgh bed on, ... 360
Saltsburg anticlinal description of, ... 46
" " Waynesburg anticlinal regarded as an exponent of, 44
" " Barren measures exposed on crest of, ... 295
" sandstone, position of, ... 76
" Waynesburg axis, irregularities of in Westmoreland co., . . . 289
Sandford & Co., Essen mine, ... 172
" mine, ... 148
Sandy creek mines. 107,108
Sapper's pit, Pittsburgh bed opened at, ... 361
Sarver & Neely, section of Pittsburgh bed mined by, ... 96
Sauters & Patterson, Briar Hill mine, ... 213
Saw mill run, a tributary of the Ohio river, ... 161
" " " coal dipping southeast towards, ... 163
" " " region mine wagon used in, ... 389
" " " railroad, ... 404
Schellenberg, F. Z., ... 416
Schmertz & Co., Little Pittsburgh mine, ... 342
School house No. 3, Stowe twp., outcrop near, ... 135
" " " 4, Pittsburgh bed outcrops near, ... 316
" " " 7, in line with Nineveh synclinal, ... 180
Shulte & Co., A. J., Bridgeville mine, ... 174
Schurings, Mr., Pittsburgh bed mined at, ... 98
Scott, Col. Thoms A., Bush colliery opened by, ... 414
Scott Haven, Ocean mine, No. 1 at, ... 307
" twp., Allegheny co., ... 165
" " Great limestone in region bordering, ... 162
" " line, Pittsburgh bed under water level along, ... 160
" " Mansfield synclinal in, ... 166
Scott's, A., opening, ... 371
" T., bank Spring Hill twp., ... 371
" Hollow, Great limestone in, ... 233

Page.

Screens used in Pittsburgh region, ... 377
Scully, Jno. S., lands of, ... 183
Searight's P. O., Woodland's pit north of, ... 360
Second Pool, coal valley mines in, ... 189
Section. Barren measures Collier twp., ... 144
“ “ “ S., of Birmingham sta., ... 163
“ Crinoidal limestone at Conahy's Knob, ... 93
“ “ “ “ Cork run tunnel, ... 157
“ Elk Lick coal bed mined on Aiken's land, ... 99
“ Ferruginuos limestone at Cork run tunnel, ... 157
“ Upper measures at Dry Hollow, ... 256
“ Upper Barren measures at Globe mine, ... 248
“ “ “ “ “ Greenfield, ... 249
“ Upper productive measures at Hasting's station, ... 156
“ “ “ “ “ Krepp's hill, ... 248
“ Upper Washington limestone at Cemetery hill, ... 204
“ Pittsburgh coal bed Allison's mine, ... 218
“ “ “ “ Amieville mine, ... 309
“ “ “ “ Bausman “ 161
“ “ “ “ Beck's run “ 176
“ “ “ “ Bellevernon, ... 342
“ “ “ “ Bells, J. M., pit, ... 134
“ “ “ “ Black Diamond mine, ... 239
“ “ “ “ Black's bank, ... 276
“ “ “ “ Boyd's mine, ... 357
“ “ “ “ Bridgeville mine, ... 174
“ “ “ “ Brisbin's bank, ... 312
“ “ “ “ Brown's entry, ... 153
“ “ “ “ Camden mine, ... 192
“ “ “ “ Catsburg mine, ... 238
“ “ “ “ Cats run, ... 365
“ “ “ “ Cedar Hill mine, ... 348
“ “ “ “ Chalfant pit, ... 117
“ “ “ “ Cheat river at mouth of, ... 281
“ “ “ “ Climax mine, ... 349
“ “ “ “ Clipper “ 244
“ “ “ “ Coal valley mines, ... 189
“ “ “ “ Coleman Co.'s pit, ... 136
“ “ “ “ Columbia mine, ... 325
“ “ “ “ Connecticut mine, ... 343
“ “ “ “ Cook's pit, ... 173
“ “ “ “ Cox's J., bank, ... 133
“ “ “ “ Crouch's pit, ... 254
“ “ “ “ Dinsmore's opening, ... 154
“ “ “ “ “ pit, ... 159
“ “ “ “ Dry run mine, ... 236
“ “ “ “ Dunkard twp., ... 280
“ “ “ “ Duquesne works, ... 117
“ “ “ “ Eclipse mine, ... 246
“ “ “ “ Eldersville, ... 223
“ “ “ “ Emmitt's mine, ... 87

Page.
Section. Pittsburgh coal bed Espey's near, ... 194
" " " " Ewing mine, ... 145
" " " " Fayetteville, ... 138
" " " " Federal Spring mine, ... 148
" " " " Fee's, John, country pit, ... 219
" " " " Field's opening, ... 281
" " " " Finley's country pit, ... 226
" " " " Flemming's & English pits, ... 104
" " " " Florence, west of, ... 211
" " " " Forsyth's opening, ... 167
" " " " Foster (old Frew) pit, ... 159
" " " " Fox pit, ... 158
" " " " Frances bank, ... 219
" " " " Frances pit, ... 353
" " " " Frazier's opening, ... 210
" " " " George's twp., line near, ... 365
" " " " Gillhall smith shop, ... 196
" " " " Gilmore's pit, ... 173
" " " " " lower pit, ... 173
" " " " Glendale mine tunnel, ... 168
" " " " Gott's pit, ... 317
" " " " Greenfield mine, ... 249
" " " " Green Spring mines, ... 187
" " " " Handenschield's pit, ... 159
" " " " Harrison mine, ... 172
" " " " Hasting's mine, ... 155
" " " " Hazen's & Burton's openings, ... 356
" " " " Hickman and Sullivan's pits, ... 282
" " " " Hopper's bank, ... 154
" " " " Irwins pit, ... 132
" " " " Jefferson twp., ... 271,212
" " " " Johnson, Mr., mine, ... 92
" " " " Jones mine, ... 198
" " " " Keystone mine, ... 119
" " " " Knob mine, ... 253
" " " " Legler mine, ... 226
" " " " Linn & Cooper mine, ... 146
" " " " Lloyd's pit, ... 136
" " " " Mack's opening, ... 365
" " " " Madison, ... 313
" " " " " south of, ... 310
" " " " Magee's pit, ... 223
" " " " Mansfield C. & C. Co's. mine, ... 137
" " " " Marshall's, Wm., drift, ... 92
" " " " Mason's, Elks, Lytle's, etc., ... 106
" " " " McBride's, ... 140
" " " " McCormack's, J., bank, ... 130
" " " " McGowan's pit, ... 194
" " " " McKee's pit, ... 183
" " " " McLaren's, ... 144
" " " " McMahon's, Hugh, bank, ... 241

Page.
Section. Pittsburgh coal bed McMillan's, Andrew, ... 173
“ “ “ “ Miller's country pit, ... 218
“ “ “ “ Miller's, A., old house, ... 185
“ “ “ “ Mingo mine, ... 235
“ “ “ “ Montgomery pit, ... 255
“ “ “ “ Montour mine, ... 139
“ “ “ “ near faults, drawing of, ... 454
“ “ “ “ Neel coal works, ... 189
“ “ “ “ Newcomer's opening, ... 365
“ “ “ “ New Texas road, ... 111
“ “ “ “ Nicholson twp., ... 131
“ “ “ “ Nolte's bank, ... 131
“ “ “ “ Nottingham No. 1, mine, ... 227
“ “ “ “ Oak Hill mine No. 4, ... 114
“ “ “ “ Oak Ridge mine, ... 150
“ “ “ “ P. C. & V. R. R. tunnel of, ... 172
“ “ “ “ Penn Gas Coal Co's. main entry, ... 310
“ “ “ “ “ “ “ “ mine No. 4, ... 309
“ “ “ “ “ “ “ “ mine, Hempfield twp., 312
“ “ “ “ “ “ “ “ N. Hunt. twp., ... 302
“ “ “ “ Phillip's, Mrs., pit, ... 255
“ “ “ “ Plummer's, ... 223
“ “ “ “ Pittsburgh & Chicago Gas C. Co. mine, . . 181
“ “ “ “ Plum creek mine, ... 109
“ “ “ “ Potter's, Henry, pit, ... 180
“ “ “ “ Primrose mine, ... 216
“ “ “ “ Puketa creek, ... 112
“ “ “ “ Rath pit, ... 193
“ “ “ “ Redd's bank, ... 241
“ “ “ “ Robertson's, A., bank, ... 317
“ “ “ “ Rock Run mine, ... 193
“ “ “ “ Rostraver mine, ... 326
“ “ “ “ Rush White's pit, ... 120
“ “ “ “ Sandy creek mines, ... 107
“ “ “ “ Sarver & Neeley, ... 96
“ “ “ “ Sharon, ... 130
“ “ “ “ Sherin's bank, ... 221
“ “ “ “ Speer's grist mill, ... 247
“ “ “ “ Stephen's & Butler's mines, ... 314
“ “ “ “ Stewart's pit, ... 141
“ “ “ “ Summer Hill mine, ... 170
“ “ “ “ Ten mile run, ... 272
“ “ “ “ Thompson's pit, ... 220
“ “ “ “ Tomlinson's bank, ... 132
“ “ “ “ Tullman & Canady's opening, ... 236
“ “ “ “ Typical, ... 446
“ “ “ “ Umpire mine, ... 354
“ “ “ “ Vandegrift pit, ... 254
“ “ “ “ Venetia mine, ... 227
“ “ “ “ Vernon's, L., property, ... 272
“ “ “ “ Washington co., ... 213

Page.
Section. Pittsburgh coal bed Walton's six mile ferry works, ... 177
“ “ “ “ Westmoreland C. Co's. mines, ... 302
“ “ “ “ White ball mine,. 307
“ “ “ “ White's, J., ... 250
“ “ “ “ Whittaker's bank, ... 211
“ “ “ “ Williams' bank, ... 98
“ “ “ “ Winebiddle est. mine, ... 104
“ “ “ “ Woods run mine, ... 245
“ “ “ “ Woodville station, ... 170
“ “ “ “ Wright's bank, ... 86
“ “ “ “ “ Franklin twp., ... 99
“ “ “ “ Youghiogheny river, ... 327
“ Sewickley coal bed Browneller's run, ... 351
“ “ “ “ Brownsville, ... 207
“ “ “ “ Burgettstown, ... 212
“ “ “ “ Cats' run, ... 368
“ “ “ “ Centre school house, ... 282
“ “ “ “ Clarksville, ... 256
“ “ “ “ Cumberland twp., ... 273
“ “ “ “ Debott's opening, ... 278
“ “ “ “ description of, ... 65
“ “ “ “ Fost's house, ... 368
“ “ “ “ German twp., ... 366
“ “ “ “ Gray's landing, ... 277
“ “ “ “ Greene co., ... 264
“ “ “ “ “ twp., ... 279
“ “ “ “ Hartley's mill, ... 277
“ “ “ “ Jefferson twp., ... 271
“ “ “ “ John's pit, ... 283
“ “ “ “ Lisbon trough, ... 340
“ “ “ “ McClellandtown, ... 340
“ “ “ “ Mifflin twp., ... 183
“ “ “ “ Monongahela twp., ... 277
“ “ “ “ Morgan twp., ... 268
“ “ “ “ Morton summit, ... 191
“ “ “ “ New Geneva, ... 370
“ “ “ “ Nicholson twp., ... 367
“ “ “ “ Parkhill's mine, ... 350
“ “ “ “ Washington co., ... 207
“ “ “ “ Westmoreland co., ... 293
“ “ “ “ where commercially unimportant, ... 340
“ “ “ “ Youghiogheny shaft, absent in, ... 305
“ Upper Freeport coal bed, Bailies Bros.' mine, ... 91
“ “ “ “ “ Belson's bank, ... 314
“ “ “ “ “ Brien's pit, ... 315
“ “ “ “ “ Dawson's mine, ... 89
“ “ “ “ “ Fulton & Beck's openings, ... 316
“ “ “ “ “ Glenshaw, ... 94
“ “ “ “ “ Grapeville, ... 296
“ “ “ “ “ Little Bull creek, ... 90
“ “ “ “ “ Little Sewickley creek, ... 18,313

Page.
Section. Upper Freeport coal bed Pugh, Mr., opened by, 90
" " " " " Thompson's pit, 315
" Washington coal bed, Washington co., 205
" Waynesburg coal bed, Bollenfield school house, 268
" " " " Bell's run, 269
" " " " Bowers', A., opening, 256
" " " " Barnard's, N., opening, 256
" " " " Brister's, Henry, 256
" " " " Buckingham's. E., 256
" " " " Bushfield's, 223
" " " " Connor's, G. W., 273
" " " " Florence, east of, 211
" " " " Harry's school house. 269
" " " " Heisterburg, S. W. of, 363
" " " " Hewson's, Mr., property, 275
" " " " Houlsworth's mills, 271
" " " " Houston school house, 273
" " " " Jefferson near, 271
" " " " Lancaster & Price, 337
" " " " Lilly's mine, 251
" " " " Little Whiteley creek, 278
" " " " McCleary's, 274
" " " " Minor's opening, 271
" " " " Pin Hook, 207,257
" " " " Ruff's creek, 269
" " " " Saw Mill run and Pigeon creek, 242
" " " " Shape's bank, 270
" " " " Stevenson's, D. C., bank, 273
" " " " Willow Tree tavern, 279
" " coal measures, Stacher's opening and Pigeon creek, 242
Sewickley twp., Westmoreland co., 99,305
" " Redstone coal bed mined in, 293
" " structural features confused in, 305
" mills, Greensburg trough canoe-shaped near, 311
" R. R. operated by Penn Gas Coal Co., 289
Shaft and slope sinking, cost of, 406
Shaft of Penn Co., 310
Shafts, description of, 421
Shafton Coal Co., 415
" " Co.'s shaft, 305
Shaler twp., Allegheny co., 93
Shaner mine, 307
Shape's, Mr., bank, section of Waynesburg coal at, 270
Sharon, section of lower division Pittsburgh bed at, 130
Shawhan's, elevation of Pittsburgh bed at, 167
Shepler pit, 198
" H., house, Flagstone quarry at, 198
" " " Fishpot limestone at. 198
" Knob, Washington limestone on, 290
Sheridan station, dip reverses at, 34
" " Brady's Bend anticlinal at, 156

Page.

Sheridan station, Crinoidal limestone at, ... 164
Sherin's bank, section at, ... 221
Shipments of coal through Monongahela river locks, ... 17
Shirland P. O., thickness of coal at, ... 138
Shupe opening, ... 317
Siebald's pit, ... 180
Sigillaria medardi(?) in Upper Washington limestone, ... 63
Simon, Mr., Elk Lick coal on lands of, ... 91
Singer, Nimich & Co.'s mills, ... 404
Slackwater of the Youghiogheny river, ... 15
Slope and shaft mining, ... 405
Slopes, description of, ... 421
Smallwood pit, ... 251
Smicksburg basin, ... 55
Smith mine, methods of mining at, ... 149
Smith's, Dr., coal opened at, ... 144
  " Mr., place, Sewickley coal at, ... 250
  " pit, ... 282
  " twp., Washington co., ... 209
Smithton, Upper Washington limestone crops out near, ... 316
  " mines, Waverly Coal and Coke Co., ... 319
Smock's station, Pittsburgh bed at, ... 357
Snodgrass', James mill, Upper Freeport coal at, ... 46
Snowden & Hogg, ... 349
Snowden station, ... 181
  " twp., ... 179
Snow Hill mine, Alps Coal Co., ... 346
Sodom, Great limestone at, ... 171
Soils of northern Allegheny, ... 86
Somerset twp., thickness of Upper Washington limestone in, ... 204
Soot veins frequent at Amieville mine, ... 309
South Butler survey by Prof. White, ... 1
  " Fayette twp., ... 147
  " Huntingdon twp., ... 316
  " " " Redstone coal in, ... 293
  " Mr., mines Waynesburg coal, ... 279
  " pit at Maples mill, ... 282
South Pittsburgh or Mount Washington, ... 161
  " Side colliery, ... 414
  " Strabane twp., Washington coal mined in, ... 205
  " West Penn. R. R., ... 288,311
Speers, James, thickness of coal at, ... 135
  " Noah, grist mill, ... 247
  " opening on Pittsburgh bed, ... 342
Spiketown workings, ... 161
Springdale twp., Allegheny county, ... 89
Spring Hill colliery, ... 414
  " " mine, ... 120
Stachers, Mr., Waynesburg coal opened at, ... 242
Staib, Lewis, Catsburg mine, ... 237
Statler's pit, ... 108

Page.

St. Clair, Gen. Arthur, ... 412
Steene, D. M., Camp Hill mine, ... 143
Steen, W. J., Federal Spring mine, ... 148
Stephens & Butler mines, section at, ... 344
Sterrett's pit, ... 35
Sterrett twp., Allegheny co., ... 115
Steubenville pike, elevation of Pittsburgh coal on, ... 139,141,210
Stevenson, Mr., Waynesburg coal opened on land of, ... 274
" Mr., opens Pittsburgh coal in Monongahela twp., ... 276
" Prof., description of fault by, ... 451
" " identification of Jollytown coal by, ... 334
" " indebtedness to, ... 3
" " notes on Washington anticlinal by, ... 36
" " section at New Geneva by, ... 369
" " section of Pittsburgh coal by, ... 317
" " surveys in Western Penna by, ... 1
" D. C., section of Waynesburg bed by, ... 273
Stewart, Dickinson & Co., ... 106
Stewart's, J. M., coal opened at, ... 132
" J., outcrop of Pittsburgh coal at, ... 154
" pit, ... 109,141,372
" W., bank, Waynesburg coal opened at, ... 268
" well record, not reliable, ... 358
Stone Bros., Coal valley mine, ... 189
Stoner & Co., Eureka mine and coking plant, ... 320
Stoner mine, ... 221
Stony Hill Coal Co's mine, ... 348
Stowe twp., Allegheny co., ... 133
Streets run synclinal, ... 179
Strubles, Mr., opening, Waynesburg coal at, ... 363
" Lower Washington limestone on land of, ... 335
Sub-carboniferous rocks in Fayette co., ... 329
Subsidence of Waynesburg axis from Bellevernon, ... 321
Sullivan's pit, ... 282
Summerhill mine, ... 169
" " section of Pittsburgh coal at, ... 170
Surface plant used in mining in Pittsburgh region, ... 375
Suter's station, measures rise rapidly at, ... 308
Sutersville, ... 309
Sutton's country pit, ... 117
Swissvale, ... 116
Syphon pipes used in Columbia mine, ... 325
" " " " Blythe mine, ... 303
Synclinals, principal synclinals in the Pittsburgh region, ... 56

T.

Table, coke shipments from the Monongahela river, ... 22
" shipments of coal through the Monongahela Navigation Co's. locks, 17
" showing average bed section in seven mines, ... 232
" variations of Pittsburgh coal, ... 78

Page.
Taggart opening, Pittsburgh bed opened at, ... 342
Tail engine plan at Rend & Co.'s mines, page plate showing, ... 396
Tailrope system of mine haulage, ... 394
Tapley's coal pit, ... 119
Taylor, Selwyn, assistance rendered by, ... 4
" " chapter on mining methods by, ... 373
" " system of mining described by, ... 153
" J. E., Waynesburg coal on property of, ... 283
Taylor's bank, ... 282
Telegraph road, Waynesburg coal bed opened on, ... 337
Temperanceville, coal measures cut by streams at, ... 162
" crinoidal limestone at, ... 156
" Saw Mill run enters the Ohio river at, ... 161
Ten Mile creek, Greene co., ... 257
" " " on the east of Morgan twp., ... 268
" " " Washington co., ... 200
Tenth limestone, plants and fish seals contained in, ... 63
Third axis same as Indiana or Blairsville anticlinal, ... 47
" limestone, *Rhizodus* in, ... 63
Thomas saw mill, Pin Hook anticlinal near, ... 225
Thompson, Edgar, steel works, ... 414
" Robert, Houston pit worked by, ... 220
Thompson station, crinoidal limestone exposed near, ... 183
Thompson's, J., pit section at, ... 220
" Mr., crinoidal limestone at, ... 99
" pit, section Upper Freeport coal at, ... 315
" run, branch of, ... 109
" " coal along, ... 187
" " location of, ... 129
" " Pin Hook anticlinal ou, ... 182
" T., bank, ... 220
Thoms Run branch of P. C. & Y. R. R., ... 142
" " or Chartiers and Cleveland mine, ... 149
Thurston, George H., review of natural gas by, ... 19
Tipples used in Pittsburgh region, ... 375,379
Titus, Mr., Pittsburgh bed opened at, ... 283
Tomlinson's bank, section of Pittsburgh coal at, ... 132
Topography of Fayette co., ... 329
" " Washington co., ... 201
Towing coal, cost of, ... 405
Townsend's pit, ... 353
Township geology, ... 300,297,268
" " of Fayette co., ... 341
" " Washington co., ... 208
" maps, details of, ... 31
Townships, arrangement of, in Southern and Western Allegheny co., . . 128
" " " " Eastern Allegheny co., ... 101
" " " " Greene co., ... 266
" " " " Northern Allegheny, ... 85
Transportation from the mines, ... 403
Troyford, Mr., Pittsburgh coal mined by, ... 132

Page.
Transportation facilities of Fayette co., 331
Troytown mines, 346
Truck and bucket used in sinking shafts, drawing of, 422
Tub Mill creek at Bolivar, 287
Tullman and Canady opening, section at, 236
Tunnels, description of, 421
Turtle creek, Westmoreland co., 288
Twelve Mile House, limestone near, 180
Typical section of Pittsburgh coal bed, 446

U.

Umpire mine, C. L. Snowden & Co., 354
Underground work, 427
Undeveloped coal territory in S. Fayette twp., 115
Union church, Pittsburgh coal bed at, 190
Uniontown—McClellantown road Pittsburgh coal on, 366
" coal bed at Markels mill, 311
" " " " Millholland's store, 166
" " " " Mt. Lebanon, 166
" " " chiefly developed at Uniontown, 338
" " " description of, 65
" " " evidently crops out near Bridgeville, 166
" " " in Cumberland twp., 273
" " " " Greene co., 264,271,279
" " " " Washington co., 207
" " " " resting on Great limestone, 228
" shales near Mingo church, 228
Union twp., Allegheny co., 160,224
" " Upper Productive measures in, 162
Upper Barren measures, characteristic features of, 61
" " " coal beds of the, 62
" " " description of, 58,202
" " " in Fayette co., 334
" " " " Jefferson twp., 222
" " " " Mt. Pleasant twp., 215
" " " " N. Huntingdon twp., 300
" " " " Sewickley twp., 305,311
" " " " Union twp., 224
" " " " Upper St. Clair twp., 170
" " " " Washington co., 202
" " " sandstone deposits of, 61
" " " thickness in Pittsburgh region, 63
Upper bench, Lower division of Pittsburgh coal, 69
" coal series, section of, 264
" division, Great Limestone, section of, 72
" Freeport coal, brought up by Brady's Bend anticlinal, 34
" " " columnar cleavage of, 315
" " " in S. Huntingdon twp., 358
" " " in Stewart's well, 358
" " " on Little Sewickley creek, 81,313

Page.

Upper Freeport coal, Big Sewickley creek, ... 311
" " " thickness of, ... 80,296
Upper Productive measures at Coal Valley station, ... 196
" " " at Dog hollow, ... 255
" " " at Florence, ... 210
" " " coal beds in, ... 64
" " " description of, ... 63
" " " in Cumberland twp., ... 272
" " " " East Bethlehem twp., ... 252
" " " " Fayette co., ... 336
" " " " Hempfield twp., ... 311
" " " " Mifflin twp., ... 182
" " " " Nicholson twp., ... 367
" " " " Snowden twp., ... 179
" " " " Spring Hill twp., ... 370
" " " " Union twp., ... 224
" " " " Upper St. Clair twp., ... 170
" " " " Westmoreland co., ... 291
" " " on Knowlton farm, ... 165
" " " section at Krepps' hill, ... 248
Upper St. Clair twp., ... 170
Upper Washington limestone, average thickness of, ... 61
" " " *calamites* in, ... 63
" " " divides upper and lower groups, . . 59,203,263
" " " in Redstone twp., ... 334
" " " *neuropteris* in, ... 63
" " " *sigillaria medardi* in, ... 63

V.

Vance's pits, ... 359
Vandevered, Mr., Pittsburgh coal on lands of, ... 99
Vandegrift pit, ... 254
Vankirk's, E., Waynesburg coal bed at, ... 338
Van Voorhis', Dr., pit, ... 237
" Pittsburgh coal bed opened at, ... 283
Veils', J., pit, " " " " 360
Venetia mine, Anderson station, ... 227
Ventilation at Laurel Hill mines, ... 153
" of mines, ... 401
Ventilating furnace, drawing of, ... 402
Venture & Chess mines, Banksville, ... 164
Venture mines, plant used at, ... 397
" " Crombie, Skillen & Co., ... 240
Vernon's, L., property, section on, ... 272
Versailles twp., Pittsburgh coal bed eroded in, ... 43
Victory mine, (Staib,) 240

W.

Walker's Mills station, ... 145
Walkin's bank, ... 253

Page.

Wallace, John, 181
  " automatic water elevator, description of, 443
  " " " " drawing of, 444
  " pit, 120
  " " Curry station, 931
  " " S. Fayette twp., 181
  " run, Jacobs' slope near mouth of, 362
Wallace & Highberger's pits on Upper Freeport coal, 314
Wall, J. Sutton, Report K^4, reference to Fort Pitt mine in, 239
  " " section in Knob mine measured by, 253
  " " Snow Hill mine described by, 346
Walters', Eph., pit, Nicholson twp., 367
Walton, Jos. & Co.'s mine, 385
  " " " drainage at, 400
  " " river opening, 197
Walton's lower mine, 197
  " new mines, 197
  " upper pit, 197
  " 2d Pool mines, 393
  " Six Mile Ferry Works, 177
  " " " " average run of coal at, 178
  " " " " section at, 178
Waltz mill, Upper Freeport coal disappears 1½ miles above, 316
  " " Pittsburgh coal passes beneath water level near, 310
War Branch run, Nicholson twp., 366
Warne, J., Waynesburg coal opened by, 242
Washington and Waynesburg R. R. in Washington co., 202
  " anticlinal, 36
  " " along E. side Chartiers twp., 217
  " " elevates Pittsburgh coal at Pittsburgh, 103
  " " elevation of " " " 155
  " " exposed on Painter's run, 36
  " " in Scott twp., 166
  " " in S. and W. Allegheny, 125
  " " in Upper St. Clair twp., 171
  " " near Chartiers creek, 170
  " " scarcely noticed in Enterprise mine, 165
  " axis, dips in Fox's pit influenced by, 158
  " " in Washington co., 200
  " " rise of measures on Knowlson farm influenced by, 165
  " Chartiers creek flows past, 201
  " coal bed, 179
  " " " of workable size in Franklin twp., Greene co., 266
  " " " in Carroll twp., 233
  " " " in E. Pike Run twp., 247
  " " " exposed on National road, 361
  " " " at Eldersville, 205
  " " " section to below Pittsburgh coal from, 301
  " " " in Fallowfield twp., 241
  " " " " German twp., 366
  " " " " Greene twp., 280

Page.
Washington coal bed, along Harman's creek, Jefferson twp., 222
“ “ “ identity in Fayette co., 335
“ “ “ in Monongahela twp., 278
“ “ “ “ Mt. Pleasant twp., 215
“ “ “ “ Sewickley twp., 305
“ “ “ section at Struble's, 335
“ “ “ “ in Washington co., 205
“ “ “ southern Smith twp., 204
“ “ “ thickness in Washington and Greene cos., 62
“ “ “ Westmoreland co., 290
“ “ “ where found and mined, 205
Washington co., description of, 199
“ “ drainage of, 200
“ “ Jollytown coal in, 204
“ “ Pittsburgh coal in, 207
“ “ Prof. Stevenson's surveys in, 1
“ “ Redstone coal in, 207
“ “ Sewickley coal in, 207
“ “ transportation, facilities in, 202
“ “ township geology of, 208
“ “ reviewed, 9
“ “ Upper Productive measures in Northern portion of, 200
“ “ Uniontown coal bed in, 207
“ “ Upper Barren series in center and southern portion of, 200
“ “ Group, 203
“ “ “ in Fayette co., 334
“ “ “ in Greene co., 263
“ “ “ limited areas in Westmoreland co., of, 290
“ “ “ thickness, 63
“ “ Limestone No. III, in, 205
“ “ “ (Middle Wash.) No. X, in, 204
“ “ “ (L. Wash.) No. II, in, 205
Washington, George, explored Westmoreland county, 411
“ Limestone No. VI, on Shepler's knob, 290
“ Sandstone separates the Washington coal beds, 205
“ township, Washington coal identified in, 335
“ “ Fayette co., 341
“ “ Redstone coal bed in, 341
Water pit, south of Hepburn church, 108
Watson's, on Smith's run, Waynesburg, coal opened at, 283
Waverly Coal & Coke Co.'s mines and coking plant, 319
Waychoff, Mr., Waynesburg coal opened on land of, 274
Waynesburg anticlinal, description of, 44
“ “ at Amieville mine, 308
“ “ “ Suter's station, 308
“ “ crosses the Monongahela near Belle Vernon, 342
“ “ in E. Bethlehem twp., 251
“ “ left butt entries of Caledonia mine rise toward, 246
“ “ not marked in Sewickley twp., 306
“ “ south of Webster, 306

Page.
Waynesburg axis, high at Bellevernon, . . . 321
“ “ (Salsburg) in Westmoreland co., . . . 285
“ “ just outside Carroll twp., . . . 233
“ “ no connection with Roaring run axis, . . . 306
“ “ passes through Webster mine, . . . 323
“ “ touches S. E. corner of Fallowfield twp., . . . 241
“ (A) coal in Washington co., . . . 206
“ “ “ persistent in Washington co., . . . 336
“ “ “ seen in Redstone, Jefferson and German twps., . 336
“ (B) “ commercially worthless in Wash. co., . . . 206
“ beds “A” and “B,” in Greene co., . . . 263
“ blackened conglomerate seen at, . . . 261
“ coal about 250′ above Pittsburgh coal, . . . 228
“ “ analysis of, . . . 267
“ “ a score of openings in Luzerne twp., on, . . . 337
“ “ available throughout Luzerne twp., . . . 337
“ “ at Garard's Fort, . . . 279
“ “ at Hickory village, . . . 215
“ “ at Minor Gray's opening, . . . 278
“ “ brought up in S. Wheeling twp., . . . 37
“ “ Existence of horizon at Florence, . . . 211
“ “ greatest developments in Greene co., of, . . . 264
“ “ in Cumberland twp., . . . 273
“ “ “ Greene twp., . . . 279
“ “ “ “ co.'s, chief source of supply, . . . 266
“ “ “ German twp., . . . 366
“ “ “ Hempfield twp., . . . 313
“ “ “ Jefferson twp., . . . 222, 270
“ “ “ Luzerne twp., . . . 363
“ “ “ Westmoreland co., . . . 291
“ “ on Little Whitely creek, section of, . . . 278
“ “ “ J. E. Taylor's property, . . . 283
“ “ “ Geo. Evan's land, . . . 278
“ “ opened at Dog Hollow, . . . 255
“ “ outcrops in road west of New Salem, . . . 361
“ “ persistent in Fayette co., . . . 336
“ “ Willow Tree tavern, section of, . . . 279
“ “ Monongahela twp., section of, . . . 278
“ “ Snowden twp.. . . . 179
“ main coal bed, description of, . . . 65
“ “ “ “ in Upper Productive coal measures, . . . 206
“ limestone position of, . . . 71
“ “ burned for lime in Hempfield twp., . . . 313
“ “ in German twp., . . . 338
“ “ “ Westmoreland co., . . . 292
“ sandstone, description of, . . . 74
“ “ in Cumberland co., . . . 273
“ “ “ E. Bethlehem twp., . . . 252
“ “ greatest development in Greene co., of, . . . 264
“ “ in Washington co., . . . 206
“ “ “ Westmoreland co., . . . 291

Page.
Waynesburg sandstont, overlies Waynesburg coal, Jefferson twp., 271
“ “ outcrops in Fayette co., 336
“ synclinal, description of, 53
“ “ in Carroll twp., 233
“ “ “ S. & W. Allegheny, 125
“ “ “ Washington co., 200
“ “ “ Westmoreland and Allegheny cos., width of, 41
“ “ western sub-division in Jefferson twp., 194
Weaver's old stand, Upper Freeport coal goes under water level at, 313
“ pit, below Fredericktown, 255
Webster's hollow, outcrop of Pittsburgh coal in, 322
“ mine, J. & W. C. Guffey, operators of, 323
Webster, Waynesburg axis at, 321
Weeks, Jos. D., History of coal field written by, 5
Weidinger's, G., pit, 177
Weir pit, Lysle & Co., 184
Welsh, Mr., Waynesburg coal formerly opened on property of, 257
Wesley's, G., Orchard or Whiteacre run pit, 185
West Bethlehem twp., Little Washington coal in, 205
“ Brownsville, Pittsburgh coal at, 251
“ “ P. V. & C. R. R., west from, 202
“ “ Upper Barren measures on Krepp's hill, west of, 247
“ Deer twp., geology of, 88
“ Elizabeth, Pittsburgh coal obliterated at, 195
“ Finley twp., Little Washington coal seen in portion of, 206
“ “ “ Upper Washington limestone in, 204
“ Lebanon basin, a sub-division of Lisbon, synclinal, 55
“ Liberty borough, erosion of Barren measures in, 162
“ Middletown synclinal, description of, 51
West Newton Co.'s shafts, 318
Western Allegheny co., Prof. White's surveys in 1876 in, 1
“ “ “ Geology of Southern and, 123
Westmoreland Coal Co., capacity of collieries of, 415
“ “ “ descriptions of cars used by, 455
“ “ “ early discovery of coal by, 411
“ “ “ Fault through collieries of, 451
“ “ “ little coal shipped west by, 9
“ “ “ mine locomotive used by, 429
“ “ “ mining methods of, 411
“ “ “ officers of, 416
“ “ “ organizers of, 414
“ “ “ shaft, Great limestone in, 292
“ “ “ South side colliery, ventilation at, 429
“ “ “ tail rope system at Osceola mine of. 431
“ “ mines at Irwin, section in, 302
“ county, drainage of, 287
“ “ formerly covered by Upper Barren measures, 62
“ “ description of, 284
“ “ Prof. Stevenson's surveys in, 1
“ “ transportation facilities of, 288
“ “ wealth of, 321

Page.
Westmoreland Gas Coal Co., mines in North Huntingdon twp., ... 301
“ shaft, ... 305
West's, Mr., bank, coal goes under water level above, ... 250
Wettengill's & Gormley's country pit, Pittsburgh coal opened at, ... 35
“ Pittsburgh coal at, ... 158
Wheeling cr., in Washington co., ... 209
“ division Baltimore & Ohio R. R. in Jefferson twp., ... 194
Whiteacre run, Pin hook anticlinal through head forks of, ... 182
White Ball mine, section at, ... 306
White, Prof. I. C., calculates fall of measures S. W. of Brady's Bend axis, 35
“ “ “ description of Pin Hook anticlinal by, ... 39
“ “ “ identification of Brady's Bend, anticlinal by, ... 34
“ “ “ surveys in Western Penn'a by, ... 1
“ “ “ surveys in Lawrence co., in 1877 by., ... 1
“ Thomas, Upper Freeport coal, mined by, ... 91
“ J., Pittsburgh coal mined by, ... 250
White's bank, elevation of, ... 221
White Rush pit, section at, ... 120
Whiteley creek, eastern portion of Greene co., drained by, ... 259
Whiskey run, Foster (old Frew pit) drains into, ... 159
Whittsett station, rapid S. E. rise of measures at, ... 351
Whittaker's bank, section at, ... 211
Wildman's on Glade run, Washington coal shows at, ... 283
Wiley P. O., Sewickley coal, South of, ... 282
Wilkins and Sterrett twps., geology of, ... 115
Williams banks, Ross twp., section of Pittsburgh coal at, ... 97
Willow Grove mines, T. B. Robins, ... 151
“ “ station, ... 151
“ Tree tavern, section of Waynesburg, bed at, ... 279
Wilson, James, ... 181
Wilson, Mr., coal mined N. E. of Bevington by, ... 212
“ “ pit, ... 142
“ William, Brush colliery opened by, ... 414
“ run, Upper Freeport coal on, ... 313
“ station, Pittsburgh coal obliterated at, ... 195
Winebiddle estate, section of Pittsburgh coal on, ... 104
Wire rope haulage, ... 392
“ “ “ drawing of, ... 430
“ “ “ at Larimer colliery, ... 431
“ “ “ “ Laurel hill mines, ... 153
“ “ “ “ Osceola mine, ... 304
“ “ system at Jumbo mine, ... 214
Withrow's blacksmith shop, Waynesburg coal near, ... 242
Wolf run station, Upper Freeport coal at, ... 358
Wolf, T. Frank, plans furnished by, ... 438
Wood, James, ... 111
“ T. J., Caledonia mine, ... 246
Wood's and McClay's pit, Chartiers twp., ... 158
“ bank, Waynesburg coal opened at, ... 337
“ “ on Dunlap's creek, ... 355
“ “ section of Waynesburg coal at, ... 363

Page.

Wood's lower pit, ... 159
" pits, Pittsburgh coal opened at, ... 360
" run, Brady's Bend anticlinal on, ... 156
" " mine, (W. H. Gregg,) 245,246
" " station, American mine below, ... 245
" " " several openings west of, ... 245
Woodville station, section of coal at, ... 170
Woodward's pit, ... 237
" " location of, ... 360
Woodward, Veil's pit S. E. of, ... 360
Wright's, Mr., section of Pittsburgh coal at, ... 98
" " bank in Franklin twp., section at, ... 86

Y.

York run, Nicholson twp., Pittsburgh coal bed along, ... 367
Youghiogheny Gas Coal Co.'s mines, ... 317
" run drains Fayette co., ... 330
" river, dams allowed to disappear on, ... 11
" slope mines, ... 317
" " " description of, ... 405
" shaft, Great limestone in, ... 292
" " record of, ... 304

Z.

Zion church, Greene twp., Pittsburgh coal bed at, ... 283

ERRATA.

Page 85, lines 10 and 15, read Leet instead of Left.
Page 100, line 13, read Leet instead of Left.
Page 132, line 24, read Twyford instead of Troyford.
Page 250, line 30, read Greenville instead of Granville.
Page 289, line 1, read Youghiogheny R. R. instead of Sewickley R. R.
Page 315, line 1, read Hunker's instead of Hunter's.

LIST OF THE PUBLICATIONS OF THE GOLOGICAL SURVEY OF PENNSYLVANIA.

FROM 1874 TO 1887.

ANNUAL REPORTS.

1885 ANNUAL. J. P. Lesley, State Geologist, 8°, 769 pp., with preface and index, accompanied by Atlas 8°, 8 pl., and maps, 1886, contains following special reports:

1. Oil and Gas. John F. Carll.
2. Vegetable Origin of Coal. Leo Lesquereux.
3. Pittsburg Coal Region. E. V. d'Invilliers.
4. Wellersburg Coal Basin. J. P. Lesley and E. B. Harden.
5. Tipton Run Coal Basin. C. A. Ashburner.
6. Anthracite Coal Region. C. A. Ashburner.
7. Wyoming Valley Fossils. C. A. Ashburner and A. Heilprin.
8. Bernice Coal Basin. C. A. Ashburner.
9. Mehoopany Coal Field. F. A. Hill.
10. Cornwall Ore Mines. J. P. Lesley and E. V. d'Invilliers.
11. Delaware and Chester Kaolins. J. P. Lesley and C. A. Ashburner.
12. Quaternary Geology, Wyoming Valley. C. A. Ashburner, F. A. Hill, and H. C. Lewis.
13. Pressure, &c., of Rock Gas. J. P. Lesley.
14. Progress Geodetic Survey. Mansfield Merriman.

1886 ANNUAL. J. P. Lesley, State Geologist, 8°, in four parts, as follows:

i. Pittsburgh Coal Region.
ii. Oil and Gas Region.
iii. Anthracite Coal Region with Atlas.
iv. Miscellaneous Reports on Special Subjects.

IN PRESS.

MISCELLANEOUS REPORTS.

A. A history of the FIRST GEOLOGICAL SURVEY of Pennsylvania, from 1836 to 1858, by J. P. Lesley. With the annual reports of the Board to the Legislature for 1874 and 1875. 8°, pp. 226, 1876.

B. Report on the MINERALS of Pennsylvania, by F. A. Genth; and on the hydro-carbon compounds, by S. P. Sadtler. With a reference map of the State. 8°, pp, 206, 1875.

B 2. Report on the MINERALS, by F. A. Genth, continued from page 207 to 238. 8°, in paper cover, pp. 31, 1876. (Bound with B.)

M. Report of CHEMICAL ANALYSES in 1874-5, in the Laboratory at Harrisburg, by A. S. McCreath. 8°, pp. 105, 1875.

M 2. Report of CHEMICAL ANALYSES in 1876-8, by A. S. McCreath; Classification of coals, by P. Frazer; Fire-brick tests, by F. Platt; Dolomitic limestone beds, by J. P. Lesley; Utilization of anthracite slack, by F. Platt; Determination of Carbon in iron or steel, by A. S. McCreath. With one folded plate (section at Harrisburg) and four page plates. 8°, pp. 438, 1879.

M 3. Report of CHEMICAL ANALYSES in 1879-80, by A. S. McCreath. With a reference map of 93 iron ore mines in the Cumberland Valley. 8°, pp. 126, 1881.

N. Report on the LEVELS above tide of railroad, canal, and turnpike stations, mountain tops, &c., in and around Pennsylvania, in 200 tables, by C. Allen. With a map. 8°, pp. 279, 1878.

O. CATALOGUE of specimens collected by the survey, (No. 1 to No. 4,264,) by C. E. Hall. 8°, pp. 217, 1878.

O 2. CATALOGUE (continued from No. 4,265 to No. 8,974); also catalogue of fossils, (pp. 231 to 239.) 8°, pp, 272, 1880.

P. Report on the COAL FLORA of Pennsylvania and the United States, Vols. 1 and 2, (bound together,) by L. Lesquereux. 8°, pp. 694, 1880.

P. Report on the COAL FLORA of Pennsylvania and the United States, Vol. 3, with 24 double page plates (lithographed) of coal plants, to accompany P., Vols., 1 and 2. 8°, pp. 283, 1884.

(P.) ATLAS of 87 double page plates (lithographed) of coal plants, to accompany P., Vols., 1 and 2. 8°, 1879.

P 2. Report on Permo-Carboniferous plants from W. Va. and Greene county, Pennsylvania, by W. M. Fontaine and I. C. White. With 38 double page plates (lithographed.) 8°, pp. 143, 1880.

P 3. Description of *Ceratiocaridæ*, by C. E. Beecher; and of *Eurypteridæ*, by James Hall. With 8 plates. 8°, pp. 39, 1884.

Z. Report on the TERMINAL MORAINE across Pennsylvania, by H. C. Lewis; including extracts from descriptions of the Moraine in New Jersey, by G. H. Cook, and in Ohio, Kentucky, and Indiana, by G. F. Wright. With a map of the State, 18 photographic views of the Moraine, and 32 page plate maps and sections. 8°, pp. lvi and 299. 1884.

GRAND ATLAS, Div. I, Pt. I, 1885, port-folio containing maps of 56 counties and parts of counties (scale 2 miles to 1 inch) on 49 sheets (26″×32″.) The maps of the remaining counties will be published in Part II. These maps are duplicate prints on heavy paper of the county maps contained in the reports of progress.

Annual Report 1886. Part iv.

ANTHRACITE REGION.

A 2. Report on the causes, kinds, and amount of WASTE in mining anthracite, by F. Platt; with a chapter on METHODS of mining, by J. P. Wetherill. Illustrated by 35 figures of mining operations, a plan of the Hammond breaker, and a specimen sheet of the maps of the Anthracite coal fields. 8°, pp. 134, 1881.

AC. Report on Mining Methods, &c., in the anthracite coal fields, by H. M. Chance. Illustrated with 54 plates and 60 illustrations in the text. 8°, pp. 574, 1883.

(AC.) Atlas containing 25 plates illustrating coal mining, to accompany Report AC, by H. M. Chance. 8°, 1883.

AA. First report of progress of the anthracite survey; Panther Creek basin, by C. A. Ashburner; with a determination of the latitude and longitude of Wilkes-Barre and Pottsville, by C. L. Doolittle; and a theory of stadia measurements, by A. Winslow. 8°, pp. 407, 1883.

AA. Second report of progress of the anthracite survey, Part 1; Statistics of Production and Shipment for 1883 and 1884. Charles A. Ashburner, geologist in charge.

(AA.) Atlas of Southern anthracite field, Part I, containing 13 sheets; 3 geological and mine sheets, 3 cross section sheets, 3 columnar section sheets, 1 topogrophical map sheet, and 1 coal bed area sheet, relating to the Panther Creek basin; 1 general map of the anthracite region, and 1 chart of anthracite production from 1820 to 1881. 8°, 1882. Charles A. Ashburner, geolosist in charge; A. W. Sheafer and Frank A. Hill, assistant geologists.

(AA.) Atlas of Western Middle anthracite field, Part I, containing 11 sheets: 4 geological and mine sheets between Delano and Locust Dale, 3 topographical sheets between Quakake Junction and Mount Carmel, and 4 cross section sheets. 8°. 1884. Charles A. Ashburner, geologist in charge; A. W. Sheafer and Bard Wells, assistant geologists.

(AA.) Atlas of Northern anthracite field, Part 1, containing 6 geological and mine sheets between Wilkes-Barre and Nanticoke, 3 cross section sheets, and 4 columnar section sheets. 8°, 1885. Charles A. Ashburner, geologist in charge; Frank A. Hill, assistant geologist.

(AA.) Atlas Eastern Middle anthracite field, Part I, containing 8 sheets—2 geological and mine sheets in the vicinity of Hazleton, Drifton, and surrounding towns, 3 cross section sheets, and 3 columnar section sheets. 8°, 1885. Charles A. Ashburner, geologist in charge; A. P. Berlin and Arthur Winslow, assistant geologists.

Grand Atlas, Div. II, Pt. I, 1884. Port-folio containing 26 sheets, (26″× 32″,) as follows: 13 sheets Atlas Southern Anthracite Field, Part I, 11 sheets Atlas Western Middle Anthracite Field, Part I, 1 sheet photo views of plaster models in Western, Middle, and Southern Fields, and 1 specimen sheet, Report A 2.

Grand Atlas, Div. II, Pt. II, 1885. Port-folio containing 22 sheets, (26″× 32″,) as follows: 13 sheets Atlas Northern Anthracite Field, Part I, 8 sheets Atlas Eastern Middle Anthracite Field, Part I, and 1 sheet containing a preliminary general map of the Anthracite Coal Fields and adjoining counties.

Note.—Single sheets of the anthracite survey, with the exception of those in the Panther Creek atlas, can be purchased by addressing Chas. A. Ashburner, geologist in charge, 907 Walnut street, Philadelphia.

For anthracite coal in SULLIVAN county, see G 2, and Annual Report, 1885.

For Conglomerate beds near Carbondale, Pittston, &c., see G 5, G 7.

For Utilization of anthracite slack, see M 2.

For General Description anthracite region, Quarternary Geology of the Wyoming-Lackawanna Valley, &c., &c., see Annual Report, 1885.

Annual Report, 1886, Part III.

BITUMINOUS COAL FIELDS AND SURROUNDING AREAS.

H. First report on CLEARFIELD and JEFFERSON counties, by F. Platt. With 8 maps, 2 sections, and 139 cuts in the text. 8°, pp. 296, 1875. (*For second report see H 6, H 7.*)

H 2. Report on CAMBRIA county, by F. & W. G. Platt. With 4 maps and sections and 84 cuts in the text. 8°, pp. 194, 1877.

H 3. Report on SOMERSET county, by F. & W. G. Platt. With 6 maps and sections and 110 cuts in the text. 8°, pp. 348, 1877.

H 4. Report on INDIANA county, by W. G. Platt. With a colored geological county map and 87 cuts in the text. 8°, pp. 316, 1878.

H 5. Report on ARMSTRONG county, by W. G. Platt. With a colored geological county map and 58 cuts in the text. 8°, pp. 338, 1880.

H 6. Second report on JEFFERSON county, (*See H above,*) by W. G. Platt. With a colored geological county map and 57 cuts in the text. 8°, pp. 218, 1881.

H 7. Second report on CLEARFIELD county, (*See H above,*) by H. M. Chance. With a colored geological county map, an outcrop map of the Houtzdale basin and 58 cuts in the text. 8°, pp. 197, 1884.

I. Report on VENANGO county, by J. F. Carll. The geology around Warren, by F. A. Randall. Notes on the comparative geology of N. E. Ohio, N. W. Pa., and W. New York, by J. P. Lesley. With one small map of the Venango oil region, one small map of the region south and east of Lake Erie, one long section of the rocks at Warren, and 7 cuts in the text. 8°, pp. 127, 1875.

I 2. Report of oil well records and levels in VENANGO, WARREN, CRAWFORD, CLARION, ARMSTRONG, BUTLER, &c., by J. F. CARLL. 8°, pp. 398, 1877.

I 3. Report on the VENANGO, WARREN, CLARION, and BUTLER OIL REGIONS; descriptions of rig, tools, &c.; survey of the Garland and Panama conglomerates, &c.; discussion of pre-glacial and post-glacial drainage, by J. F. Carll. With 23 page plates and an atlas. 8°, pp. 482, 1880.

(**I 3.**) Atlas of 22 sheets. Map of Venango county, colored geologically; map of lower oil field (Butler, Armstrong, and Clarion,) in two sheets; 3 local contour maps at Franklin, Titusville, and Spring Creek; two maps of N. W. Pennsylvania, showing the past and present drainage; long section across W. Pennsylvania; vertical section of the formations from the Upper Coal Measures down to the bottom of the Devonian; diagram map and section of Third sand; profile section from Meadville, S. W.; 5 sheets of grouped oil well sections; 5 sheets of working drawings for well boring, &c.; diagram of daily rate of drilling six wells at Petrolia.

I 4. Report on WARREN county, by J. F. Carll. With a colored geological county may, a map of the Warren oil region, and 2 sheets of oil well sections.

G 2. Report on LYCOMING and SULLIVAN counties; field notes by A. Sherwood; coal basins by F. Platt. With two colored geological county maps, (of Lycoming and Sullivan,) a topographical map (in two sheets) of the Little Pine creek coal basin, and 24 page plates of columnar sections. 8°, pp. 268, 1880.

G 3. Report on POTTER county, by A. Sherwood. Report on its COAL FIELDS, by F. Platt. With a colored geological county map, 2 folded plates and 2 page plates of sections. 8°, pp. 121, 1880.

G 4. Report on CLINTON county, by H. M. Chance, including a description of the Renovo coal basin, by C. A. Ashburner, and notes on the Tangascootac coal basin, by F. Platt. With a colored geological county map, 1 sheet of sections, local Renovo map, 6 page plates, and 21 sections in the text. 8°, pp. 183, 1880.

G 5. Report on SUSQUEHANNA and WAYNE counties, by I. C. White. With a colored geological map of the two counties and 58 cuts in the text. 8°, pp. 243, 1881.

G 6. Report on PIKE and MONROE counties, by I. C. White. With two colored geological county maps, (1 sheet Pike and Monroe and 1 sheet Wyoming,) a map of glacial scratches, and 7 small sections. Report on the Delaware and Lehigh Water Gaps, with two contoured maps and five sections of the gaps, by H. M. Chance. 8°, pp. 407, 1882.

G 7. Report on WYOMING, LACKAWANNA, LUZERNE, COLUMBIA, MONTOUR, and NORTHUMBERLAND counties, (*i. e.*, the parts lying *outside* of the anthracite coal fields,) by I. C. White. With a colored geological map of these counties, (in two sheets,) and 31 page plates in the text, 8°, pp. 464, 1883. (*Note.—The colored geological map of* WYOMING *county is published in G 6.*)

T. Report on BLAIR county, by F. Platt. With 35 cuts in the text, and an Atlas of maps and sections, (see below.) 8°, pp. 311, 1881.

(T.) Atlas of colored geological contour line map of Morrison's cove, Canoe valley, Sinking valley, and country west to the Cambria county line, (14 sheets:) Index map of the same, (1 sheet;) colored sections, (2 sheets.) 8°, 1881.

T 2. Report on BEDFORD and FULTON counties, by J. J. Stevenson. With two colored geological maps of the two counties. 8°, pp. 382, 1882.

T 3. Report on HUNTINGDON county, by I. C. White. With a colored geological map of the county, and numerous sections. 8°, pp. 471, 1885.

T 4. Report on CENTRE county, by E. V. d'Invilliers; also special report, by A. L. Ewing, and extracts from report to Lyon, Shorb & Co., by J. P. Lesley. With a colored geological map of the county, 13 page plates of local maps and sections, and 15 cuts in the text. 8°, pp. 464, 1884.

For report on line of the Terminal Moraine, see Z.

GRAND ATLAS, Div. IV, Pt. I, 1885. Port-folio containing 43 sheets, as follows: 30 sheets relating to the Durham and Reading Hills and bordering valleys in Northampton, Lehigh, Bucks, and Berks counties, and 13 sheets relating to the South Mountains in Adams, Franklin, Cumberland and York counties.

GRAND ATLAS, Div. V. Pt. I, 1885. Port-folio containing 35 sheets, as follows: 29 sheets relating to the Topography and Geology of the Palæozoic strata in parts of Cambria, Blair, Bedford, Huntingdon, Mifflin, Centre, and Union counties, 5 sheets contain a map and geological cross section along the east

See Annual Report, 1885, for report of progress in the oil and gas region, with special facts relating to the geology and physics of natural gas.

See Grand Atlas, Div. III, Pt. I, under Bituminous Coal Fields.

See Annual Report 1886. Part II.

NORTH-EASTERN AND MIDDLE PENNSYLVANIA.

(*Palæozoic formations from the Coal Measures down.*)

D. First report on Lehigh county iron mines, by F. Prime. With a contour line map of the ore region and 8 page plates. 8°, pp. 73, 1875.

D 2. Second report on Lehigh county iron mines, by F. Prime. With a colored geological contour line map of the iron region, (in 4 sheets,) a colored geological contour line map of the Ironton mines, 4 double page lithograph pictures of Limestone quarries, and one page plate of *Monocraterion.* 8°, pp. 99, 1878.

D 3. Vol. 1. Report on Lehigh and Northampton counties. Introduction by J. P. Lesley; Slate belt, by R. H. Sanders; Limestone belt and iron mines, by F. Prime; South mountain rocks, by F. Prime and C. E. Hall. With 3 lithograph pictures of quarries, 4 pictures of triangulation stations, 14 page plates of sections, and an atlas of maps. 8°, pp. 283, 1883. (*Note.—For atlas see below.*)

D 3. Vol. 11, Part I. Report on Berks county, (*South mountain belt,*) by E. V. d'Invilliers. With 10 page plates of sections and Indian relics, and 3 pictures of rock exposures. 8°, pp. 441, 1883. (*Note.—For atlas see below.*)

(**D 3.**) Atlas: One colored geological map of *Lehigh* and Northampton counties, (*one sheet;*) one colored geological contour line map of Southern Northampton county, (*six sheets;*) a contour line map of the mountains from the Delaware to the Schuylkill, (*eighteen sheets;*) a colored geological contour line index map to the 22 sheets, (*one sheet;*) and 4 sheets of maps of Iron mines.

(**D 5.**) Atlas of colored geological county maps of Cumberland, Franklin, and Adams, (*three sheets*); and first instalment of contour line map of the South mountains, Sheets A 1, A 2, B 1, B 2, (*four sheets,*) by A. E. Lehman.

F. Report on the Juniata river district in Mifflin, Snyder and Huntingdon counties, by J. H. Dewees, and on the Aughwick valley and East Broad Top region in Huntingdon county, by C. A. Ashburner. With colored geological maps of East Broad Top R. R. and Orbisonia vicinity, (2 sheets;) Three Springs map and section, (2 sheets;) Sideling Hill Creek map and section, (2 sheets,) and Isometric projection at Three Springs, (1 sheet;) six folded cross sections and 22 page plates of local maps and columnar sections. 8°, pp. 305, 1878.

F 2. Report on Perry county, (*Part 1, geology,*) by E. W. Claypole. With two colored geological maps of the county; 17 geological outline township maps as page plates, and 30 page plate cross and columnar sections. 8°, pp. 437, 1884.

G. Report on Bradford and Tioga counties, by A. Sherwood; report on their coal fields, (including forks of Pine creek in Potter county,) by F. Platt; report on the coking of bituminous coal, by J. Fulton. (*See L above.*) With two colored geological county maps, 3 page plates, and 35 cuts in the text. 8°, pp. 271, 1878.

R 2. Part II, report on township geology of CAMERON, ELK, AND FOREST counties, by C. A. Ashburner.

(R 2.) ATLAS for CAMERON, ELK AND FOREST counties, of 11 sheets (*published November, 1884, in advance of the report*) :—3 colored geological county maps; 1 anticlinal and synclinal map; 1 topopraphical map McKean county; 2 tract maps Forest and Elk counties; 1 map Straight Creek coal basin; 2 sheets oil well sections; and 1 sheet coal sections.

V. Report on N. BUTLER county; and (Part 2) special report on the Beaver and Shenango river coal measures, by H. M. Chance. With a colored geological map of N. Butler; a contour local map around Parker; a map of the anticlinal rolls in the 6th basin; a chart of the Beaver and Shenango rivers; profile section from Homewood to Sharon; Oil well records and surface sections; and 154 cuts in the text. 8°, pp. 248, 1879.

V 2. Report on CLARION county, by H. M. Chance. With a colored geological county map, a map of the anticlinals and oil-belt; a contoured map of the old river channel at Parker; 4 page plates, and 83 cuts in the text. 8°, pp. 232, 1880.

For the coal basins of BRADFORD and TIOGA counties see report G.

For the coal basins of LYCOMING and SULLIVAN see report G 2.

For the coal basins of POTTER county see G 3.

For the coal basins of CLINTON county see G 4.

For the coal in WAYNE county see G 5.

For the East Broad Top coal basin in HUNTINGDON county see F.

For the mountain coals in BLAIR county see T.

For the Broad Top coal measures in BEDFORD and FULTON counties see T 2.

For the coal basins in CENTRE county see T 4.

For coal analyses, see M, M 2, M 3.

For classification of coals, see in M 2.

For coal plants, see P, P 2.

For fossil crustaceans in coal slate, see P 3.

For Origin of Coal; Pittsburgh Region and Monongahela Valley; Wellersburg coal basin, Somerset county; and Tipton Run coal-beds, Blair county, see Annual Report, 1885.

Grand Atlas Div. III, Pt. I, 1885, port-folio containing 35 sheets (26″×32″) as follows: 32 sheets relating to portions of the Petroleum and Bituminous Coal-fields, and 3 sheets relating to the Quarternary period.

Annual Report 1886. Part I.

PETROLEUM AND GAS.

See reports I, I 2, I 3, I 4, and J, under Bituminous Coal Fields.

See L, for the Pittsburgh gas well, and the use of gas in the iron manufacture.

See Q, Q 2, Q 3, Q 4, for references to oil rocks in Beaver, Lawrence, Mercer, Crawford, Erie, and S. Butler counties.

See K for the Dunkard Creek oil wells of Greene county.

See R, R 2, for descriptions of oil rocks in McKean, Elk, and Forest counties.

See V, V 2, for notes on the oil rocks of N. Butler and Clarion counties.

See H 2 for oil boring at Cherry Tree, Cambria county.

See G 5 for oil boring in Wayne county.

8°, pp. 439, 1883. (*Note.—The first 147 pages of this book contain oil well records; see under Petroleum Fields below.*)

J. Report on the OIL REGION, by H. E. Wrigley; map and profile of line of levels through Butler, Armstrong, and Clarion, by D. J. Lucas; map and profile of Slippery Rock creek, by J. P. Lesley. 5 maps and sections, a plate and 5 cuts. 8°, pp. 122, 1875.

K. Report on GREENE and WASHINGTON counties, by J. J. Stevenson. With two county maps. (Showing the calculated local depths of the Pittsburg and Waynesburg coal beds beneath the surface,) and 3 page plates of general sections. 8°, pp. 419, 1876. (*Note.—Since the publication of this book two colored geological county Maps have been published, and will be found in pocket of volume K 3 described below.*)

K 2. First report on FAYETTE, WESTMORELAND, and S. E. ALLEGHENY counties, (*i. e.*, west of Chestnut Ridge) by J. J. Stevenson. With 3 colored geological county maps and 50 cuts in the text. 8°, pp. 437, 1877.

K 3. Second report on FAYETTE and WESTMORELAND counties, (the Ligonier Valley,) by J. J. Stevenson. With 4 page plates and 107 cuts in text. 8°, pp. 331, 1878. (*Note.—In a pocket in this volume will be found the colored geological maps of Greene and Washington counties alluded to above.*)

K 4. Pt. I, Report on the MONONGAHELA river COAL MINES, from the West Virginia State Line to Pittsburgh, (including some on the Youghiogheny and other streams,) by J. Sutton Wall. With a map of the region in a pocket, 12 heliotype pictures, and 26 page plates. 8°, pp. 231, 1884.

L. Report on the YOUGHIOGHENY coke manufacture, by F. Platt; Notes on the coal and iron ore beds, by C. A. Young; Report on methods of coking, by J. Fulton, (*See G* below;) Report on the use of natural gas in the iron manufacture, by J. B. Pearse and F. Platt; The Boyd's Hill gas well at Pittsburgh, by J. P. Lesley. With a map of the coke region, two folded plates of coke ovens, and page plates and cuts in the text. 8°, pp. 252, 1876.

Q. Report on BEAVER, N. W. ALLEGHENY, and S. BUTLER counties, by I. C. White. With 3 colored geolocial county maps, and 21 page plates of sections. 8°, pp. 337, 1878.

Q 2. Report on LAWRENCE county, and special Report on Correlation of the Pennsylvania and Ohio coal beds, by I. C. White. With a colored geological county map and 134 cuts in the text. 8°, pp. 336, 1879.

Q 3. Report on MERCER county, by I. C. White. With colored geological county map and 119 cuts in the text. 8°, pp. 233, 1880.

Q 4. Report on CRAWFORD and ERIE counties, by I. C. White. With two colored geological county maps and 107 cuts in the text. Also, a Report on a pre-glacial outlet for Lake Erie, by J. W. Spencer. With two maps of the Lake region. 8°, pp. 406, 1881.

R. Report on MCKEAN county, and its geological connections with Cameron, Elk, and Forest counties, by C. A. Ashburner. With 33 page plates of vertical and columnar sections, pictures of Rock city and Olean conglomerate, Wilcox and Kane spouting wells, map of Howard Hill coal field, &c., and an atlas of 8 sheets. 8°, pp. 371, 1880.

(R.) ATLAS for McKean county of 8 sheets:—Colored geological county map; three topographical maps; of Buffalo Coal Company tract, Alton coal basin, and Potato Creek coal basin; map of McKean oil disirict; one sheet of columuar sections between Bradford and Ridgway: and 2 diagram sheets of the Well account and Production account in the Bradford district.

bank of the Susquehanna river, Lancaster county, and 1 sheet contains cross sections of the Philadelphia belt of the Azoic rocks.

For report on Cornwall Iron Ore Mines, Lebanon county, and the Tipton Run coal-beds, Blair county, see Annual Report, 1885.

SOUTH-EASTERN PENNSYLVANIA.

C. Report on YORK and ADAMS counties, by P. Frazer. With one folded map of a belt of York county through York and Hanover, 6 folded cross sections, and two page plate microscopic slices of dolerite. 8°, pp. 198, 1876. (*Note.—The colored geological county map of* YORK *is published in the* ATLAS *to C 3.*)

C 2. Report on YORK and ADAMS counties, (South Mountain rocks, iron ores, &c.,) by P. Frazer. With one general map of the district, 10 folded cross sections, and 5 page plates. 8°, pp. 400, 1877. (*Note.—The colored geological county map of* ADAMS *is published in D 5.*)

C 3. Report on LANCASTER county, by P. Frazer. With nine double page lithographic views of slate quarries and Indian-pictured rocks, one plate of impressions on slate, and one page plate microscopic section of trap, and an atlas. 8°, pp. 350, 1880.

(C 3.) ATLAS of 13 sheets: Colored geological map of York county; colored geological map of LANCASTER county; Susquehanna river section. (Sheets 1, 1 A, 2, 2 A, 3, 4;) Lancaster section: Pequea section;, Muddy run section; Chestnut Hill mines; Gap Nickel mine.

C 4. Report on CHESTER county; General Description, pp. 214, by J. P. Lesley; Field Notes in the townships, pp. 215–354, by P. Frazer. With a colored geological county map, a photographic view of contorted schists, and 12 page plates. 8°, pp. 394, 1883.

C 5. Report on DELAWARE county, by C. E. Hall. With a colored geological county map; 30 photographic page plate views of granite quarries, kaolin pits, &c., and 4 page plates of altered micas. 8°, pp. 128, 1885. See Annual Report, 1885, for Kaolin Report.

C 6. Report on PHILADELPHIA and the southern parts of MONTGOMERY and BUCKS counties, by C. E. Hall. With a colored geological map of the belt of country between Trenton and Delaware county, (in 3 sheets,) a sheet of colored cross sections, and 24 cuts in the text. 8°, pp. 145, 1882.

E. Part I of (historical introduction to) a report on the AZOIC rocks, by T. S. Hunt. 8°, pp. 253, 1878.

For report on the kaolin deposits of CHESTER and DELAWARE counties see Annual Report, 1885.

See also GRAND ATLAS, Div. V. Pt. 1, under North-eastern and Middle Pennsylvania.

July 1, 1887.